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THE NEW WATER SUPPLY FOR CINCINNATI, O., has progressed to such a point that bids will soon be asked for the pumping station at California, on the Ohio River. The pumps at this station will lift river water to the purification works. The building will rest on the circular walls of the pump well and will have an inside diameter of 98 ft. and a height of about 85, making a total height of about 170 ft. from the bottom of the pump well to the apex of the roof. There will be a 60 × 180-ft. boiler house and an annex 50 × 55 ft. The walls of these buildings will be of Bedford limestone, or equally good material. The roofs will consist of steel framework, covered with tiles. The pump house roof trusses will have a span of 101 ft., c. to c. of pins. The chimney, as now planned, will be of brick, 8 ft. inside diameter and 175 ft. high. The pump house will contain four 30,000,000-gallon pumping engines, contract for which has already been awarded. The pump pit, tunnel beneath the river, intake pier, and connecting bridge of 320-ft. span, have been completed for some months, and a house over the intake pier is now being built. Mr. Gustave Bouscaren, M. Am. Soc. C. E., is chief engineer of the new works. We are indebted for the above information to Mr. C. N. Miller, Assoc. M. Am. Soc. C. E., assistant in charge of office.

AN EARTH DAM is being built by the hydraulic process on Dobbins Creek, Cal., a few miles above the Colgate power house of the Bay Counties Power Co., described in our issue of Oct. 3, 1901. The reservoir to be created by the dam will impound 93,000,000 cu. ft. of water. The level will be 382 ft. above the main flume to the Colgate power house.

A HEAVY RAINSTORM occurred in Cincinnati, O., about 10.45 a. m. on May 20, giving a precipitation of 2.31 ins. in 38 minutes, according to the report of the local office of the Weather Bureau. This exceeds the precipitation of the storm of May 14, 1881, which was 1.14 ins. in 20 minutes. The heaviest rainfalls in 24 hours were 2.08 ins., May 25, 26, 1879; 2.47 ins., May 27, 28, 1882, and 2.43 ins., May 1, 1894. Since 1871 all the record storms have occurred in May, with the exception of 1897, when 1.90 ins. fell during one hour on July 5. The storm of May 20 caused the deaths of seven persons and the injuries of many others by the collapse of buildings, the flooding of cellars, and the overturning of wagons, etc., by the torrents on some of the streets. In the hilly parts of the city tons of debris were washed down the streets, carrying away lamp posts and other obstructions, so that in some places street car traffic was stopped. Buildings were also blown down by the wind and undermined by the water. The city engineer, Mr. Stanley, reported that great damage has been done to the streets, especially where improvements were in progress, and the Board of Public Service made an appropriation of $10,000 to make temporary repairs and to increase the street cleaning force so as to remove the debris without delay.

A HEAVY RAINFALL AT BERLIN, GERMANY, is reported in the "Schweizerische Bauzeitung," which states that on April 14, 1902, the precipitation amounted to 200 to 400 liters per hectare per second, or nearly 6 ins. of depth per hour. The duration of the storm is not given, but it appears to have been long for so high a rate, since in speaking of the previous maximum (300 liters) it is stated that this continued but a few minutes.

THE WATER POWER AT THE "SOO" is to be extended during the present season by the construction of a third canal, as suggested in the description of the works at the Soo in our issue of Jan. 9, 1902. The new canal will bring the total power developed at that point by the Clergue syndicate to over 100,000 HP. The additional power is to be utilized by electrometallurgical works and paper mills.

THE MOST SERIOUS RAILWAY ACCIDENT of the week occurred on the Detroit & Mackinac Ry., near Black River, Mich., on June 8. A crowded excursion train was partly wrecked while running at a fair rate of speed. The wreck was caused by the tender leaving the rails; three coaches were derailed and smashed up. Only one person was killed, but about fifty others were injured more or less severely.

A TEST OF GUNS VS. ARMOR PLATE, recently held at Eskmeals, resulted in a decided victory for the quick-firing Vickars guns and the Johnson capped-projectile. The plates were Krupp process cemented steel, 6 ins. and 12 ins. thick, made according to British Admiralty specifications. The first attack was on a 12-in. plate, and the first round was from a 6-in. gun with a Johnson-capped projectile and a striking velocity of 2,799 ft. seconds. This shot completely perforated the plate, though the projectile was broken up. The second shot—without a cap, penetrated only 3¾ ins.; the third shot—an explosive shell, was buried deep in the plate. In a second trial, a 6-in. capped shot again went through the plate; while one without the cap was broken up. A test, on May 23, with 6-in. and 7.5-in. guns, with capped projectiles, again showed victory for the guns; both projectiles passed through, the 7.5-in. explosive shell being bedded in a sand heap beyond the target; a 6-in. shot, without the cap, made no impression on the plate. The Johnson cap used is an American invention, and is simply a cylindrical forged steel cap, with the bottom bored out to fit over the nose of the projectile. It is put on by hydraulic pressure, and thus forced into a groove cut around the point, with a nick in the groove to prevent rotation.

THE CENTENNIAL OF THE FOUNDING of the U. S. Military Academy at West Point has been celebrated this week by a gathering of the alumni officers of the army, including ex-Confederate officers. The Military Academy was founded April 15, 1802, with Jonathan Williams, Major of the Corps of Engineers, as its first Superintendent. The Chief of Engineers, U. S. A., was ex-officio Inspector of the Military Academy from 1818 until 1866, when the law was changed permitting the Secretary of War to assign any officer to that duty. In a similar manner, previous to the passage of the law of 1866, the Superintendent of the Academy was always selected from the Corps of Engineers, and up to 1889, 14 out of 22 Superintendents belonged to that corps.

THE "KRONPRINZ WILHELM," of the North German Lloyd Co., in her last trip from New York to Cherbourg and Bremen, made the trip to Eddystone Light at an average speed of 23.53 knots per hour. This is the best eastward speed record made on the Atlantic. The "Deutschland" has a record of 23.51 knots over a course of 3,082 knots, while the distance made by the "Kronprinz Wilhelm" was 3,095 knots. The daily runs of the latter ship were 434, 550, 535, 534, 552 and 490 knots.

THE OIL-CARRYING BARKENTINE "FULLERTON" was launched at Oakland, Cal., recently, and she is the first exclusive oil-carrier to use sails as a motive power. The "Fullerton" will carry 15,000 barrels of oil, or 2,500 tons; she carries this cargo in bulk in 16 compartments, eight on a side. In each of these is a 10-in. pipe and valve, making it possible to fill or empty any one compartment. The wooden bulkheads dividing the compartments are 10 ins. thick. To obviate danger from fire, the vessel will be lighted by electricity generated by a gasoline engine; the same power operates the oil pumps, which have great capacity. This ship is owned by the Union Oil Co.

THE WABASH R. R. EXTENSION TO PITTSBURG will be 60 miles long, starting from the Wheeling & Lake Erie R. R. at Jewett, O. It is being built by two separate companies, under the names of the Pittsburg, Carnegie & Western R. R. and Pittsburg, Toledo & Western R. R. for the Pennsylvania and Ohio divisions of the road respectively. It will be double track throughout, with maximum grades of 0.66%, and its sharpest curves will be of 3°. The principal structures will be the two great cantilever bridges over the Ohio and Monongahela Rivers, noted in our issue of March 27. There will be 14 tunnels, varying in length from 500 ft. to 4,400 ft.; ten of the tunnels being located on a division of 22 miles. The passenger terminal will be at Liberty Ave. and Ferry St., but no plans have yet been completed for the terminal or the station. Work is in progress on the entire line, and the road is expected to be completed by February, 1903. Mr. J. W. Patterson, of Pittsburg, Pa., is chief engineer of the entire line from Jewett to Pittsburg.

A NOVEL METHOD OF ASH REMOVAL is in use at the Charlestown Power Station of the Boston Elevated Railway. The boiler equipment at this station consists of seven 500-HP. Babcock & Wilcox water-tube boilers, supplying steam to two horizontal cross-compound Allis engines of 1,000 HP. each, and one vertical cross-compound Westinghouse engine of 4,500 HP. normal capacity. The steam is condensed by two Allis condensers and one large Bulkley jet condenser. The overflow from the condenser pumps flows off through longitudinal tunnels which pass along under the ash pits of the boilers. The ash pits are arranged to permit of the ashes being dumped into the tunnel, where the rapidly moving water carries them away. The tunnels discharge out upon low-lying flats a short distance from the power station, and here the ashes are deposited by the water and serve as filling.

A CIVIL SERVICE EXAMINATION for computer in the U. S. Coast and Geodetic Survey will be held on July 8 and 9 by the United States Civil Service Commission. The examination will include algebra, plane and solid geometry, trigonometry, elements of calculus and practical computations which will have, respectively, the following weights: 10, 10, 15, 15, 50. This examination is open to males and females aged 20 years or over. From the eligibles resulting from this examination it is expected that certification will be made to the position of computer in the Coast and Geodetic Survey, at a salary of $1,000 per annum, and to other similar vacancies as they may occur. This examination is open to all citizens of the United States who comply with the requirements. Competitors will be rated without regard to any consideration other than the qualifications shown in their examination papers, and eligibles will be certified strictly in accordance with the civil service law and rules. Persons who desire to enter this examination should at once apply to the United States Civil Service Commission, Washington, D. C., or to the secretary of the local board of examiners, for application Forms 304 and 375, which should be properly executed and promptly filed with the Commission at Washington. Persons who are unable to file their application, but whose requests are received at the Commission in sufficient time to ship examination papers to the places selected, will be examined.

TIE AND TIMBER PRESERVING PLANTS are now being established by several railways and lumber companies. Two portable plants are being built for the Union Pacific Ry. and the Oregon Short Line. Each plant is for the burnetising process, and has two steel cylindrical retorts mounted on trucks, the retorts having flange joints at the middle, so that they can be separated for transportation. The engine and boiler for operating the hauling cable for the tie trams is mounted on a car, and the pumps, steel tanks for chloride solution, etc., are mounted on other cars. The general design is similar to that of a plant in use on the Southern Pacific Ry. The retorts, tanks and other parts are being built by the Chicago Bridge & Iron Co., and Mr. Samuel M. Rowe, M. Am. Soc. C. E., of Rowe & Rowe, Consulting Engineers, 226 La Salle St., Chicago, has charge of the inspection of the work at the shops. Mr. Rowe has recently completed a two-retort plant (using the Wellhouse process) for the Alamogordo Lumber Co., and has the plans ready for the three-retort plant of the Rocky Mountain Timber Co. The four-retort Wellhouse plant designed by him for the Great Northern Ry. at Kalispell, Mont., has a capacity for treating 1,200,000 ties per year, and has now been in operation for a few months.

A SALT LAKE, the water containing 25 to 30% salt, is described by the English Consul at Buenos Ayres. This lake lies in the southern portion of the Province of Buenos Ayres, Argentina, near San Blas. The rock-salt deposit underlying the lake is pierced by several springs; a syndicate is now working the deposit by running the water from these springs into banks, allowing it to settle, and then forcing it through iron pipes to the coast, 26 miles off. At the coast the water runs into evaporating pans. The syndicate is capitalized for $600,000, and is now turning out 25,000 tons of salt per annum, but the output could be increased to 100,000 tons. The Bay of San Blas is 800 miles south of Buenos Ayres; it has a deep channel and sheltered anchorage, and the syndicate is building a pier to facilitate loading.

THE HYDRAULIC AIR COMPRESSOR AT NORWICH, CONN.

By Herbert M. Knight.*

For nearly two years there has been under construction, and now is nearing completion, the first installation in the United States of an hydraulic compressor for the compression of air without any other agency than the energy and static head of falling water. This installation is situated at Taftville, in Eastern Connecticut, on the Quinebaug River, some three miles above Norwich, to

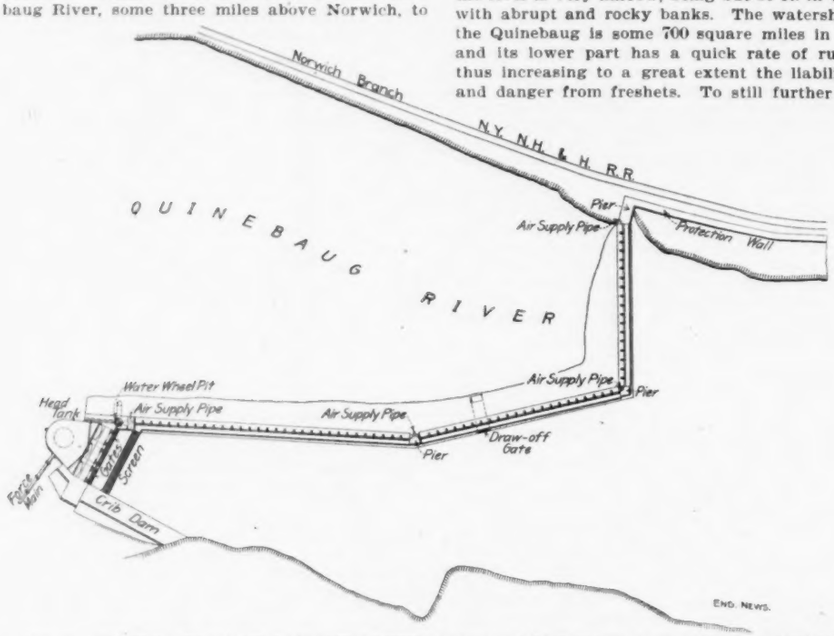

FIG. 1. GENERAL PLAN OF DAM FOR HYDRAULIC AIR-COMPRESSING PLANT ON QUINEBAUG RIVER, NEAR NORWICH, CONN.

which city the air is to be conveyed after compression for general power distribution.

The special form of installation is that known as the "Taylor system of hydraulic compression," a few examples of which have been in successful operation in Canada for some two or three years, notably at Magog, Quebec, and Ainsworth, British Columbia.

No long or detailed description of this form of air compression would seem to be necessary, as the principle was known in the beginnings of industrial history in the well-known Catalan forges. And yet, despite its simplicity and economy, it has remained a comparatively unused and unknown method of power production until very recent days.

Briefly stated, the action of the hydraulic compressor consists in the passage of a stream of water from a higher elevation, either natural or caused by impounding, by or through a head-piece so designed as to permit of the water entraining air through the production of a vacuum caused by the rapid flow of the water past the bottom of tubes whose lower ends are immersed in the falling water and whose tops are at all times open to the atmosphere. After passage through the head-piece the column of water and air is led vertically downward through a tube or shaft excavated to that depth which will give the requisite pressure, determined by the weight of water whose height is the distance measured from the bottom surface of the air in the tank or reservoir at the bottom of the shaft to the elevation of the surface of the water in the tail-race. After its passage to the bottom of the vertical shaft, the combined air and water are released in an air-tight chamber, so designed by its greater size as to facilitate, both by retarded velocity and increased length of passage, the separation of the air and water. The air rises by reason of its greater buoyancy to the upper part of this chamber, from whence it is removed in pipes, and the water, relieved of its burden of air, flows outward under the edge of the chamber and upward around the outside of the tube.

The present installation furnishes several engineering points of interest, not only because of the originality of the scheme proposed, but also on account of some of the problems in construction and in the details of design.

The location selected for the site of the dam and shaft was at that point on the Quinebaug River two miles above tidewater where it breaks through a natural rocky formation and near its union with the Shetucket River. At this point the river is very narrow, being but 60 ft. in width, with abrupt and rocky banks. The watershed of the Quinebaug is some 700 square miles in area, and its lower part has a quick rate of run-off, thus increasing to a great extent the liability to and danger from freshets. To still further complicate this problem, the northern bank of the river is occupied by the Norwich branch of the New York, New Haven & Hartford R. R., with its roadbed at an elevation that would have rendered it liable to injury from high water in case the dam had been built across the gorge at its narrowest part. The result of these conditions was the construction of a dam nearly in the form of a letter Z, some 600 ft. below the narrowest part of the gorge, with a spillway length under ordinary conditions of 432 ft. As a further safeguard to the roadbed of the railway company, a protection wall has been carried along its track to such a height as will effectually guard it against any freshet up to a height of 11 ft. on the crest of the dam.

The dam, which has a minimum height of 30 ft. above bedrock and a maximum height of 45 ft., is of that character of construction known as "rubble" or "cyclopean" concrete. It has a front batter of 0.6 ft. per ft. rise and a batter on back or 0.06 ft. per ft., with a peculiarly designed crest, upon which are placed the automatic flashboards, to be described later.

The material composing the concrete of which the dam is constructed consisted of broken stone and gravel excavated from bars in the Quinebaug and Shetucket rivers in close proximity to the work. The gravel was absolutely clean in character, uniform in composition and of an excellent mixture in graded sizes for the work. It was all water washed and completely free from earthy and vegetable matter and without any admixture of clay or loam. Being deficient in sand, especially of the finer sizes, to make the graded mixture which was desired, there was added to it such proportions of sand determined by sieve tests as would give the mixture required. A certain fixed amount of very fine sand was always required, slightly coarser than the cement, to prevent the passing of the latter away in the moist mixture made and used. The gravel, extra sand and cement were put together in measuring boxes, after which they were elevated to the top of the concrete mixer. A cubical mixer was used of the Cockburn-Barrow Co.'s make, and the usual batch was 22 cu. ft. after mixing.

The kind of concrete and degree of plasticity desired was that known as "moist concrete," of such a degree of softness as would insure homogeneous work and the entire absence of voids without recourse to ramming and permit the introduction of the large masses of rock which were added and give certainty that no voids or hollows would exist in their beds. The only work done on concrete after depositing in place was to spade it against forms and around large rock aggregates and to thoroughly force into it the smaller aggregate which were added subsequent to depositing. The amount of water necessary to bring the batch to the required plasticity was determined by a special form of measuring apparatus, so designed that while it permitted the same quantity of water to be used on all batches, it was very easily and quickly changed and regulated to suit any variation due to changes in the amount of moisture contained in the gravel as brought.

Into this matrix or primary mixture, after depositing, were introduced large aggregates, consisting of the rock excavated from the shaft and large boulders removed from site of dam foundation. These were in such sizes as the rock came out of the shaft, the limit of size being the capacity of the derricks and machinery to handle the material, and the elevation in the dam at which they were to be placed, stones aggregating from 2 to 2½ cu. yds. having been used in some instances in the bottom of the dam. Around these larger stone were placed other rock, gradually reducing in size to that which could be placed by hand, until the size of stone was reached constituting the largest aggregates of the primary mixture, the purpose being to present a constantly descending scale from the largest to the very smallest constituents. All of the larger aggregates were thoroughly washed with water before depositing, both to remove all surface dirt and to prevent absorption of water from the concrete. In placing the stone into the concrete it was al-

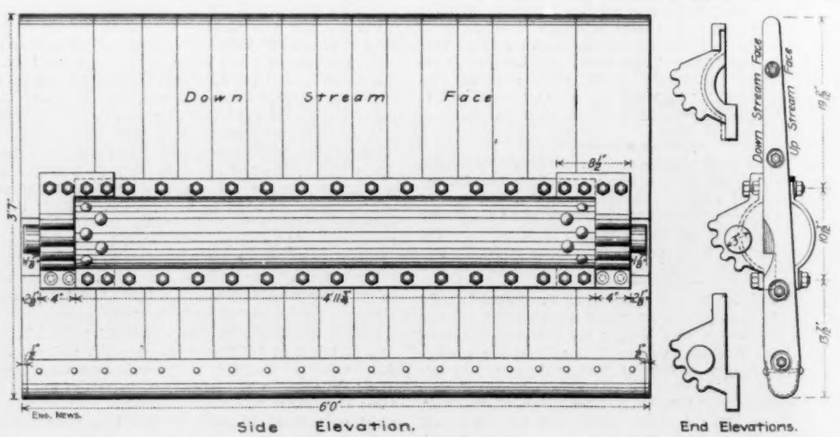

FIG. 3. SIDE AND END ELEVATIONS OF AUTOMATIC FLASHBOARDS.
Shedd & Sarle, Engineers, Providence, R. I.

*Norwich, Conn.

ways insisted upon that a mass of concrete sufficiently large and plastic should exist to permit of their settling into the same and forming a positively voidless bed. The stone was so introduced as to present the heavier and larger aggregates in that portion of the cross-section of the dam where their weight would be most effective in increasing its stability.

No special precautions were taken to present a finished exterior surface, the character of workmanship and of material being uniform throughout the cross-section. The forms were made of

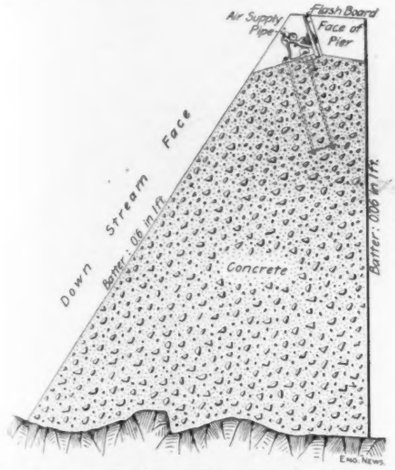

Fig. 2. Cross-Section of Dam Showing Automatic Flashboards.

ordinary spruce lumber, planed on the side next the work. After the removal of the planking, the surface was washed with a very thin grout to fill up all surface pits.

The excavation of the dam was in every instance carried down to bedrock of a satisfactory character upon which to found the masonry, but no trough or channel was excavated in the rock as a dentil for the bottom of the dam. The underlying rock was of a very firm and dense structure and irregular in elevation, and it was deemed unwise to shatter it in the excavation of any channels. Some areas of inferior rock in the river bed in that part of the dam parallel to the stream were encountered, all of which was removed, and in the arm of the dam across the stream a bed of large boulders and gravel had to be excavated to a depth of nearly 15 ft. before masonry could be started.

spring manifested itself, covering these with burlap bags, and then piping vertically from the cavity. The concrete was then deposited around and over the bags without washing, the water flowing through the pipe and away until the surrounding masonry was completely set, when the pipe and chamber in the bottom were completely closed by forcing in grout under pressure to absolute refusal. In every case the springs so treated failed to give further trouble or to manifest themselves in the dam or at new locations in the foundation area.

Before depositing any concrete, either upon the bedrock or upon concrete previously set, the surfaces were washed and scrubbed to remove all dirt and foreign material, and the fresh concrete was immediately placed thereon, no cement wash or mortar layer being introduced, it not being desired to introduce any uniform condition in any part of the cross-section or to divide any portion from any other part by any marked line of cleavage.

The headwall does not join the hillside, but on the south side of the pond a crib dam closes the space between the bank and the headwall, the purpose of this comparatively temporary structure being to permit of the construction of other shafts for the utilization of high and freshet waters, if deemed advisable, as explained later, while the present plant continues in operation, and present no serious difficulties in its subsequent removal.

Work on the construction of the dam was begun in October, 1899; was continued through the following year and until March, 1901.

Some 12,000 cu. yds. of concrete were placed and something over 1½ cu. yds. of concrete was secured per barrel of cement, this large percentage being obtained neither by a weak or adulterated mixture, but by the use of large masses completely imbedded in the primary concrete.

The head gates, which are three in number, are on the east face of the head gate wall, which is at the west end of the dam, and are 11 ft. 8 ins. square, closing openings 11 ft. square, through which the water enters the compressor. These gates present no specially noteworthy features, except that they are raised or lowered either singly or all together by a water wheel, shown on the north side of the headwall, the shaft for which is connected with the forebay through a gate in the rear of the screen rack. A system of levers is provided, so connected that the throwing of one lever engages either one of a pair of large bevel gears over the water wheel pit, and the gate, whose movable clutch-gear is in mesh with the gear on drive shaft, will be raised or lowered, as desired. This dispenses with the need for

varying heights of water, being connected therewith by a train of gears.

One of the most interesting and novel features of the entire installation is the automatic flashboards on the crest of the dam. These consist of

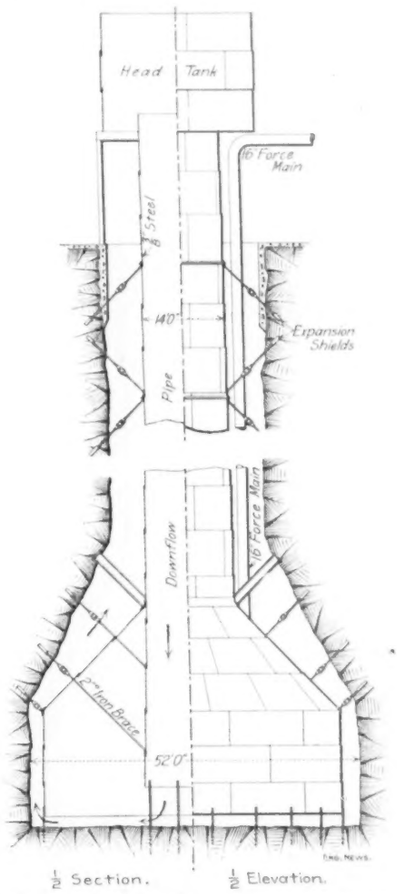

Fig. 4. Sectional Elevation of Hydraulic Air Compressor.

leaves or shutters of oak in close units, 6 ft. long and 3 ft. 7 ins. wide, pivoted at such a point in their width as will permit of their revolving from an upright to a nearly horizontal position as the

FIG. 5. CONCRETE DAM UNDER CONSTRUCTION, SHOWING SIZE OF STONES EMBEDDED IN MATRIX.

FIG. 6. NARROW GORGE ON QUINEBAUG RIVER 600 FT. ABOVE DAM.

At a few points in the foundation, especially in those portions where unsatisfactory bedrock had been removed, springs were met with. These were uniformly treated by making a small cavity of larger stones over the spot at which the

hand manipulation, although means are provided for handing the gates in this way if necessary. This water wheel is also to be used for raising and lowering the head-piece of the compressor to secure proper immersion of the tubes with

water rises, the rolling being regulated by the movement of a peculiarly designed toothed cam attached to the boards over a steel rack bolted to a cast-iron pedestal securely fastened to the crest of the dam by anchor bolts. These flashboards

were in service during the winters of 1900-01 and 1901-02, and were subjected to heads from the top of flashboards to 6 ft. 9 ins. over the crest of the dam. Under these heads their action was very satisfactory, assuming a nearly horizontal position at the greater head specified and returning to an upright position and retaining the water in the pond when the water surface had fallen to 9 ins. above the normal elevation of the top of the board. By these boards the full effect of the spillway is secured in time of freshet, but at a point 3 ft. lower than the top of the flashboards when up-

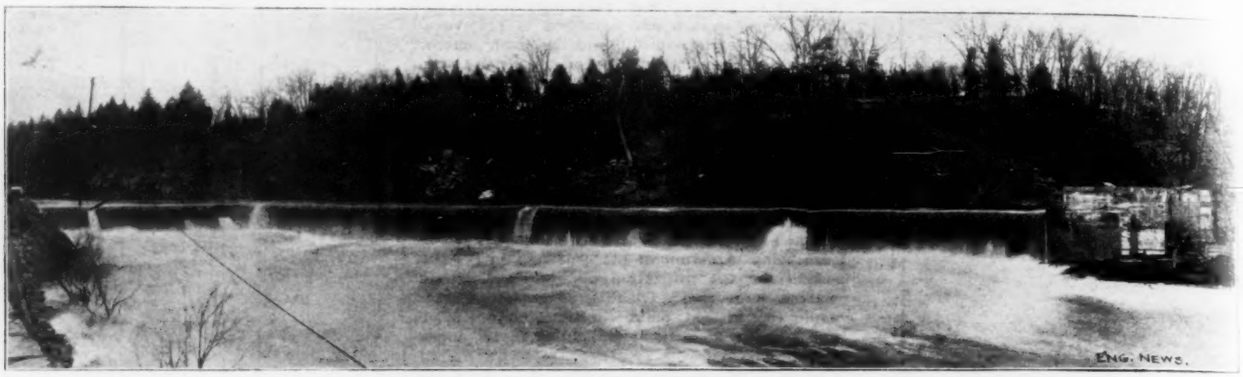

FIG. 7. FRESHET OF APRIL 9, 1901; 6 FT. OF WATER ON CREST OF DAM.

right, and also a full pond to the crest of the flashboards is at all times retained. These automatic flashboards are the invention of Mr. J. Herbert Shedd, Consulting Engineer for the Power Company, and Mr. O. Perry Sarle, Jr., of Providence, R. I.

One other feature of interest is the introduction of pipes into the end and intermediate piers, where purpose is to supply air on the underside of the sheet of water as it comes over the flashboards and so overcome the vacuum which otherwise would exist on the face of the dam caused by the withdrawal of the air by the water. Frequent tests during the freshets of the winter of 1900-01 were made of these pipes to ascertain their action, and it was found that they would draw in heavy canvas when large quantities of water were flowing over the crest of the dam. By this arrangement the extra pressure on the back of dam due to a vacuum more or less perfect on face is removed.

The shaft in which the compressor is located is circular in cross-section and of a diameter of 24 ft. for a depth of 100 ft. From this point it enlarges to a diameter of 52 ft, below which point it is continued as a chamber of this diameter for 18 ft., the total depth of shaft and chamber being 208 ft. below the river bed.

In the center of the shaft is the downflow pipe, 14 ft. in diameter, built of ⅝-in. steel plates. The entire chamber is occupied by the air or separating tank, in which the separation of the air from the water takes place. This is a large circular tank of similar material to the downflow, with vertical sides and a conical roof. At its highest point connection is made for the 16-in. riser main, supplying the distribution system. There is also attached to the air tank a safety pipe rising to the atmosphere, whose bottom reaches such an elevation, and whose diameter is such as to prevent, in case of a large accumulation of air in chamber and tunnel, the water ever being forced below the bottom of downflow pipe and returning upward therein, with consequent injury to the head-piece. This pipe is designed to quietly exhaust into the atmosphere all air which may be compressed after the line of separation of air and water has reached a certain desired point. Both downflow and air tank are strongly supported and rigidly secured to the sides of the shaft to guard against collapse or vibration. The braces which perform this work are of 2-in. round iron, and these are fastened to a hole drilled in the walls of the shaft by a double expansion shield nut, into which the brace fits with a collapsible thread. These shield nuts were manufactured by the New Jersey Foundry & Machine Co., were easily put in position, and have performed their service with entire satisfaction.

The head-piece, in which collection takes place, is situated vertically over the top of the downflow, and is connected with the headwalls by a short rectangular penstock, which is continued around the head-piece, forming a head tank to supply water to the head-piece and compressor. The head-piece consists of a large number of tubes, whose lower ends are immersed in the descending column of water and whose upper ends are open to the atmosphere. Means are provided for operating the head-piece for securing the proper immersion of the tubes and for regulating the amount of water passing through the head-piece.

Air from the compressor is taken to the city of Norwich in a pipe line some four miles [illegible] of cast-iron pipe 16 ins. in diameter [illegible] the course of its location it was necessary to carry it under water a distance of some 400 ft., [illegible] in a body of water whose maximum depth was [illegible] ft. No joint other than that almost universally used on the line was adopted, as it is very flexible and tight. The pipe was lowered from the ice upon a bed previously prepared and afterward covered with gravel and boulders.

The pipe were all plain tubes without head or bell. The joint adopted was a double gasketed joint, in which two square rubber rings are compressed against the pipe between the beveled edges of a sleeve and collar, closely fitting the pipe at each joint. The construction of the pipe line presented no problems different from those met with in ordinary pipe line work. In the city of Norwich mains have been laid in the principal thoroughfares in the business section, leading to either positive or prospective users of compressed air power.

Work on installation of the downflow, air tank and head-piece was not started until April, 1901, and at the present writing the compressor is nearly completed.

The plant is owned and is being installed by the Continental Compressed Air Power Co. of Philadelphia. Mr. J. Herbert Shedd, Consulting Engineer, of Providence, R. I., designed the dam and supervised the construction thereof and the excavation of the shaft. Mr. William O. Webber, M. E., of Boston, Mass., was designing and supervising engineer for the compressor, and the loca-

FIG. 8. POND ABOVE DAM DRAWN DOWN. AUTOMATIC FLASHBOARDS IN VARIOUS POSITIONS, PROTECTION WALL ALONG RAILWAY IN THE BACKGROUND.

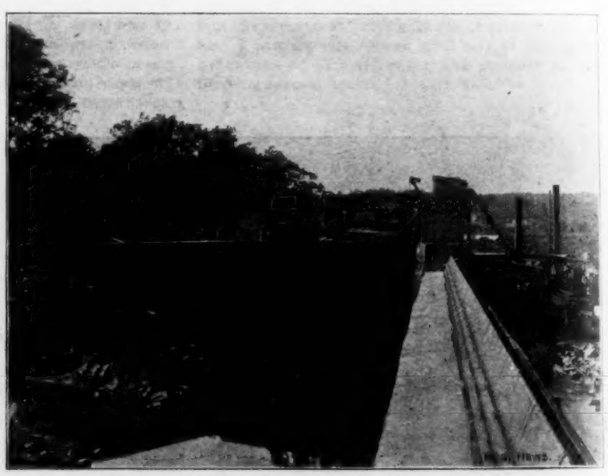

FIG. 9. VIEW OF FOREBAY, SHOWING CRIB-DAM, SCREEN-RACK, HEAD-GATES AND FLASHBOARDS IN NORMAL POSITION.

tion and construction of the pipe line was under the direction of Mr. Taylor Gleaves, Consulting Engineer, of Lynchburg, Va. The writer has been Resident Engineer of the several parts of the work.

THE RUDDER BOOM.

By Halbert Powers Gillette.*

In a recent issue of Engineering News of July-Dec., 1900, p. 398, a description of the Snoqualmie Falls (Wash.) power plant is given, and incidental mention is made of a "rudder boom." The rudder boom is a device very commonly used by Western shingle mill operators for the purpose of diverting floating cedar "bolts" into a pocket-boom, where they are caught, and carried up by an endless chain conveyor into the mill, where they are sawed into shingles.

The application of the same device to diverting drift wood from the intake of the pipe, at Snoqualmie Falls, is an example of the inventive resources of American engineers.

There are undoubtedly many engineers in the East who have never seen, and possibly have never heard, of a rudder boom, but the instances where it can be used to advantage are not few in number. At Niagara Falls, for example, the ice that is drawn into the penstocks in the spring of the year seriously interferes with the operation of the turbines, yet trouble from this source could be entirely avoided by the use of the rudder boom. So far as the writer is aware no published description of such a boom exists, neither is there any published data for computing the dimensions of the rudders, etc.

In 1893, the writer was inspecting some bridge work close to a shingle mill, where one of these booms was being built, and watched with interest the progress of the building. Before it was launched out into the river, the writer, having applied his theoretical mechanics to the problem, ventured the prediction that more rudders would be required to carry the boom out to the desired angle with the current. The builder, a practical man, had little respect for anything theoretical, and hearing the prediction he lost no time in offering to wager a box of cigars that the boom would work as it was. It is doubtful whether the writer, who had no great confidence in his own theory, would have accepted the wager, but for the greater fear of ridicule that would follow be-

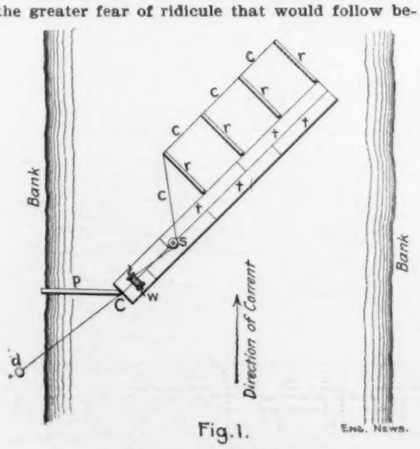

Fig. 1. The Rudder Boom.

ing "bluffed." The boom was finished and finally launched, and swung gracefully out into the current until it reached its limiting angle. The builder continued to smoke a pipe while he sawed the wood for more rudders!

When first seen, the rudder boom looks very much like an example of "lifting yourself over a fence by your boot straps;" for the same river current which tends to force a long stick pivotally connected at one end to the bank, into a position parallel with the bank itself, is made to carry that same stick out until it forms an acute angle with the current and stays there.

Fig. 1 shows the boom after it has assumed a position of equilibrium in the river. The behavior of the rudder boom, however, differs in no wise from that of a kite; for the river current corresponds to the air current; the boom corresponds to the kite string, and the rudders correspond to the kite itself; therefore, a rudder-boom might not inaptly be called a river-kite.

As commonly built the boom consists of two lines of 12 × 16-in. timbers (t), bolted together and arranged so as to break joint. Hinged to the down-stream side of the boom are the rudders or "fins" (r), made of 3 × 16-in. plank standing edgewise in the water, spaced about 12 ft. apart; each being about 12 ft. long.

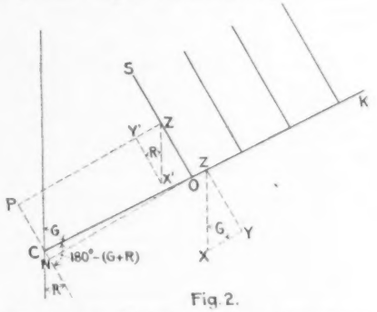

Fig. 2.

Fig. 2. Diagram Illustrating Computation of Rudder Boom's Position.

The free ends of the rudders are fastened to a small wire cable (c), passing around a sheave (s) to the drum of a winch (w), which is mounted on the boom itself.

The boom is anchored to the river bank with another wire cable fastened to a deadman or tree (d), and its end is held away from the bank by a short strut (p). When first built the boom lies anchored parallel with the river bank, but when finished the cable (c) is wound up on the drum of the windlass by men using cranks, until the rudders assume an angle with the current which impinging upon them drives the boom, rudders and all, out into the stream. It then assumes the position shown in Fig. 1, where the moment of the force of the current upon the boom just equals the sum of the moments of the force of the current acting upon the rudder, the centre of moments being C. Were it not for certain indeterminate factors, the exact position that the boom would take under given conditions might be calculated; as it is, a very close approximation can be made by the formula that will be presently deduced.

Assuming that the force of the current acting upon the boom is practically the same in pounds per square foot as is the force acting upon the rudders, it will appear from the formula that the velocity of the current is immaterial, and a given rudder boom will assume the same position in a river, whether its velocity is two miles an hour or ten. Practically, there is some difference in the pressure upon booms and rudders, for the current loses some velocity in passing under the boom before it reaches the rudders, due to eddies generated. Furthermore, the direction of the current as it rises from under the boom and strikes the rudders is not exactly horizontal.

There is, however, another factor that in a measure counterbalances this lost velocity, for the velocity of a river current is greater in the center of the stream than near the bank; and, if properly constructed, most of the rudders will be located near the center of the stream, so as to receive the greatest possible impact; while few if any rudders will be located near the bank end of the boom.

In the demonstration that follows we shall assume the force, f, of the current to be uniform upon both boom and rudders, and we shall neglect the small factor of tangential friction of the water upon the boom and rudders. External forces like wind and accumulated drift will also be ignored, although they have at times a marked effect, especially where the river velocity is low.

In Fig. 2 let C K be the boom pivoted at C, and O S be one of the rudders hinged at O, and let X Z be the direction of the river current. Draw X Y parallel with C K, and Z Y perpendicular to C K, then if X Z = f be the unit pressure of the river current, Y Z will be the normal unit pressure upon the boom. Likewise draw X′ Z′ parallel with the current, Z′ Y′, perpendicular to the rudder, O S, then Y′ Z′ will be the unit current force normal to the rudder.

Let G = the angle Z X Y that the boom makes with the current.

R = the angle Z′ X′ Y′ that the rudder makes with the current.

l = length C K of boom in feet.

r = length O S of rudder in feet.

x = distance of hinged end of rudder from center of moments, C.

f = pressure of current, lbs. sq. ft.

d = submerged depth of boom in ft.

d′ = submerged depth of rudder in ft.

M = moment of boom about C.

M′ = moment of a rudder about C.

Draw C P parallel with O S, Z′ P parallel with C K, O Z′ being = Z′ S, and draw O N parallel with P Z′. Then,

$$Y Z = X Z \sin G. \quad (1)$$

$$= f \sin G. \quad (2)$$

$$M = \frac{l}{2}(l\,d)\,f \sin G. \quad (3)$$

$$Y' Z' = X' Z' \sin R. \quad (4)$$

$$= f \sin R. \quad (5)$$

$$M' = C P\, r\, d'\, f \sin R. \quad (6)$$

$$C P = \frac{r}{2} - x \cos(180 - G - R). \quad (7)$$

$$M' = r\, d'\, f \sin R \left[\frac{r}{2} - x \cos(180 - G - R)\right]. \quad (8)$$

If there is equilibrium $M = \Sigma M'$ and

$$\frac{l^2}{2} d\, f \sin G = \Sigma\, r\, d'\, f \sin R \left[\frac{r}{2} - x \cos(180 - G - R)\right]. \quad (9)$$

Since f appears as a factor in both members of eq. 9 it may be dropped, showing, as above stated, that the force of the current is immaterial.

From eq. 9, given the length, and submerged depth of boom, and the angle at which it is desired to hold it, one may calculate the number, size and location of rudders, and by a few approximations, the angle of maximum efficiency R may be calculated, R being ordinarily about 45°, or a max. value of R may be determined by the well-known differential coefficient method of calculus.

In minor ways the writer has employed the rudder boom principle many times to advantage. Once for example, it was desired to carry a cord across a swift stream where partially submerged rocks made rowing dangerous. A small "river-kite" served admirably.

The "Siwashes" or coast Indians of the far west use the same principle in "cordelling" their canoes up swift rivers; in so doing, one Siwash stands in the stern with a pole that he uses in poling the canoe up stream, while another Siwash walks along the bank with a rope that is fastened to bow and stern of canoe, so as to keep the long axis of the canoe at an angle with the river current, thereby keeping the canoe out away from the bank.

In floating a grillage of 12 × 12-in. sticks out into the center of a river where it was to be sunk upon submerged piles; the writer has also used the river-kite principle to advantage, and other uses will occur to any engineer engaged on work in or about rivers.

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COLD WORKING SHEET METAL IN DIES.*

By J. D. Riggs,† Jun. M. Am. Soc. M. E.

During the last half century a marked progress has been made in the art of working sheet metal. The introduction of more elaborate machinery and tools, and the change from hand work to die work, has brought about some very radical changes, both in the design of articles made of sheet metal and in the cost of producing them. The development of this art has led to the use of sheet metal in the construction of a great many articles formerly made of wood or cast metal. As an example of what we often meet with I may mention that while visiting Cincinnati two years ago, I was shown parts for the body of a violin which had been stamped in dies from an aluminum bronze. These violins were said to be excellent instruments.

Dies operated by presses do a large share of the work of manufacturing sheet metal goods, and are useful in cutting out irregular forms cheaply and accurately, but

*Abstract of a paper presented at the Boston meeting (May, 1902) of the American Society of Mechanical Engineers.

†Pittsburg, Pa.

their usefulness does not end here, for an endless variety of bending, drawing, and forging operations may be done by them, some bending or drawing operation often being combined with the cutting out and performed together with it. One of the most common pieces produced in dies is the end of an ordinary tin can. Referring to Fig. 1, this piece is cut into a round disk and then the annular portion, b, is drawn to the cylindrical form, p.

The problem of finding the depth of cup which a disk

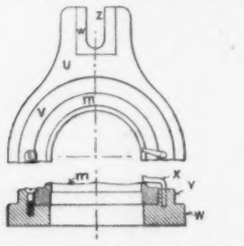


Fig. 3.

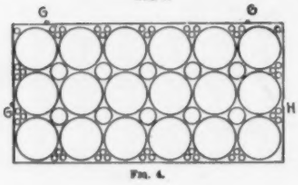


Fig. 4.

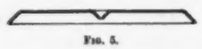


Fig. 5.

Fig. 6.

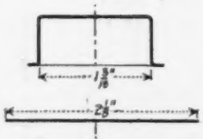


Fig. 7.

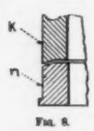


Fig. 8.

Fig. 9.

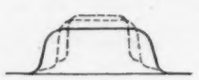


Fig. 10.

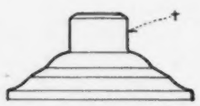


Fig. 11.

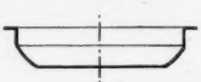


Fig. 12.

Fig. 13.

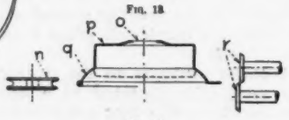


Fig. 14.

or "blank" will make may be solved by equating areas of cylindrical ring, p, and annular ring, b.

$$\pi Cd = \pi (C + b)\, b = \pi Cb + \pi b^2.$$

Reducing and allowing for stretch,

$$p = b + \frac{b^2}{C} + s$$

And as the corner is always more or less rounded, we may say

$$p = b + \frac{b^2}{C} + s + \frac{r}{2}$$

where s represents the stretch or elongation of the metal in the edge, p, and varies from 0 to 5% of p, in tin plate or steel; r represents the radius of the rounded corner. The diameter of the blank is represented by

$$C + 2b$$

Fig. 2 shows a typical die as used in single-acting presses for forming can ends and similar articles. The right side shows the die closed while the left side shows the relation of parts when open. The hardened steel ring, m, and the steel edge, k, of the punch, i, cut out the disk or blank. As the press continues to descend, the ring, n, clamps the annular part against the face of the punch, k, and produces a considerable tension in the metal as it is drawn over the central portion, l. As the die opens the ring, n, "strips" the finished piece up from l. Ring, n, is actuated by a spring through pins, g, and has adjustment by means of a nut on the lower end of the stud bolt, t. Both rubber and steel springs are in use, but either should be amply long. The die (collectively) consists of the die and the punch. When dies are required for cutting only, the die may be made as shown in Fig. 3.

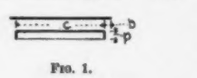


Fig. 1.

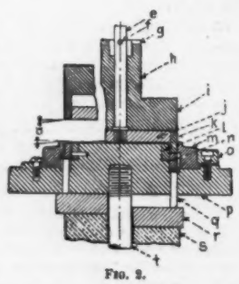


Fig. 2.

A concern extensively engaged in the manufacture of tin cans has been using for some time dies similar to that shown in Fig. 2, in "gangs." They leave off the stem, h, from the punch and recess the body, i, of several into a large plate, and instead of the small plate, p, a large one is used with many dies set into it. In this manner gang dies are made to cut the alternate large disks shown in Fig. 4, and the sheet is then turned over from right to left, and the remaining large disks cut and formed into can ends. The die rings, m, Fig. 2, interfered with cutting all the large disks at one stroke. The remaining sheet is then laid aside, to be afterward put into another gang die, which cuts and forms the remaining disks into can caps, shown in Fig. 5, and button blanks, shown in Fig. 6. The dies for each group of three small disks, and corresponding to m, Fig. 3, is made in one piece, which allows of cutting and forming the 52 pieces at one stroke of the press. Although this gang die formed two distinct articles, it did not mix them together, as the can caps came out on top of the die and slid back in the inclined press, while the button blanks formed on the peculiar punch shown in Fig. 6, and went through the die. It will be observed that this sheet of tin is not standard size, but is 11 × 22 ins., which was a very difficult size to get 15 years ago. Gages, G, Fig. 4, and notching die, H, were so arranged that the irregularity of the sheets would not be reproduced and interfere with using the second set of dies.

The depth which may be drawn at one operation is commonly expressed as equal to half the diameter for small cups and one-third or one-fourth for larger vessels. Fig. 7 shows a tin cup formed at once in a die represented by Fig. 2, with the exception shown in Fig. 8. The radial edge of the cup was required, and less than a square corner for the cutting edge of the punch was desirable. This concave face of the punch, K, together with a hardened and nicely polished ring, n, gave excellent results.

Where a depth greater than can be drawn in one operation is required, or a small boss is wanted near the center of a sheet, it becomes necessary to resort to two or more operations, forming a larger and shallower piece first, and then reducing this to the desired form.

An interesting example of this class of work was shown in operation at the Pan-American Exposition. The can-top shown in Fig. 11, ready for rolling a thread at t, was first cut and formed to the shape shown in Fig. 10, by a die of the type shown in Fig. 2. It then passes through some four other dies and through the forms indicated by dotted lines in Fig. 10, the last one of these dies cutting the hole in the top, trimming and turning the outer edge and shaping it up generally, but not materially reducing the diameter of the boss.

Another example of this reducing is found in one form of bicycle front fork-crown, where a boss is formed to which to attach the fork-stem.

In deep-drawn work the edge becomes irregular, and is often trimmed again before finishing the piece. In Fig. 9 the outer line is drawn directly from the piece shown in section in Fig. 10, while the inner line is a circle drawn to illustrate the peculiar irregularity of the edge, showing as is common four high points. I attribute these high and low points to the rolling mill which rolls the sheets.

Passing to work done in double-acting presses, Fig. 12, shows a piece formed of tin plate in a die shown in Fig. 15, where the outer punch, b, descends, cuts out the blank, and, during its "dwell," clamps the disk against the ring, g, while the inner punch descends just far enough to give the required shape. This piece, Fig. 12, is then put into a die, Fig. 16, where the outer punch, i, clamps the tapering portion against the die, and the inner punch descends just far enough to produce the piece shown in Fig. 13. This piece is next put through a single-acting die, which cuts the holes o and p, and rounds the base at q somewhat more. The piece is now put into a l... Fig. 14, which carries a pair of rotary cutters, r, on ... back, and a curling roll, n, on the front end of the c... slide. After this lathe has trimmed and curled the ... the piece goes into a bath of hot palm oil to have its ... of tin re-shined, and is then ready to have other p... attached and form the oil-well of a tubular lantern.

The trimming cutters, r, and the curling roll, n, ... used in a variety of ways, either together or separat... Three of these rolls are often put into a body and f... a chuck, to be used in a machine similar to a drill pr... to curl the edge of pails and round vessels. If the ... shown in Figs. 15 and 16 had been made open bottom, ... the inner punches had been adjusted lower, the pi... produced would have been a cylindrical cup instead of ... shown in Fig. 13.

In drawing and reducing bright steel I have found ... possible to draw to 9 ins. diameter, anneal and reduce ... 6 ins. diameter at one operation; but this is rather t... much, from 8 to 6 ins. is much better. When the side ... a cup is to be used as a seamless band without flang... either inside or out, the tool shown in Fig. 17 will be ... service in a lathe.

It is often necessary to turn a flange around a hole, ... but this is found a very different problem from turning ... an outer edge. In turning out a flange ¼-in. high around ... a 2-in. hole in IXX tin so many pieces were spoiled by ... cracking at the edge that we made new dies and drew the ... stock in, before cutting the hole. These holes were ... punched 1⅜ ins. when turning them out to form a ¼-in. ... edge around a 2-in. hole. Another case of this kind was ... done by hand tools instead of in a press, and proved entirely successful. In Fig. 18, R represents a section of a steel bicycle wheel rim through the hole for the valve-tube. The ⅝-in. valve-tube required a 13-32-in. finished hole. The rim was first drilled to one-third of the finished size. The hand-punch, made to the finished size of the hole with the pilot, n, 1-32-in. larger than the drilled size, was driven through with six or eight blows of a hand hammer, while the "hold ob," q, weighing some 3 lbs., was held up with a light spring. Block, o, with ½-in. hole, p, was held in a bench vise. The material was No. 16 gage, and reduced to about half this thickness without cracking. The rims were stiffer through this re-enforced hole than elsewhere.

Some work with straight sides and sharp angles may be cut out in dies such as shown in Fig. 19, which con-

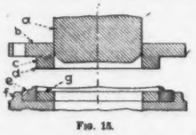


Fig. 15.

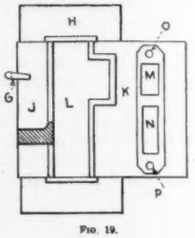


Fig. 19.

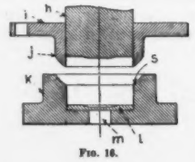


Fig. 16.

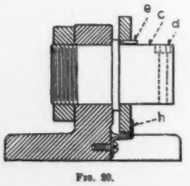


Fig. 20.

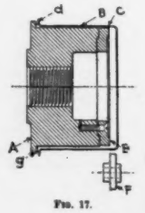


Fig. 17.

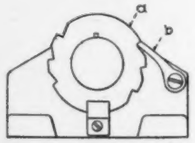


Fig. 21.

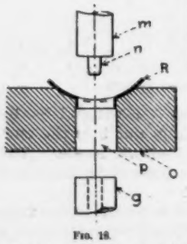


Fig. 18.

Fig. 22.

sists of four hardened steel pieces attached to a cast-iron base. I have not found this to materially reduce the cost of the dies, but the straight sides of both punch and die may be ground true after hardening and in this way improve the work. The pawl and ratchet may be used in various forms for spacing holes or notches. Figs. 20 and 21 show the construction of a horn die used to punch holes in the side of a cylinder. In this case a notch in the edge of the work engaged the pin, e; the operator

...rned to the left until the pawl dropped into a notch and ...hen held to the right while punching a hole. Ratchets ...e used for notching armature stampings where the ...tchet is somewhat smaller in diameter than the work ...d lies horizontal.

Work on the side of a cylinder is commonly done in a ...rn press where a horn similar to c, Fig. 20, is attached ...ectly to the back of the press.

The particular construction to adopt in making a die ...l often depend on shop conditions and tools available. ...e die shown in Fig. 2 contains the hardened ring, m, ...d the soft tool-steel ring, k. These rings should be ...de weldless, and k may be either welded or brazed to ...he machine-steel punch body, i, while m should be ...ground on the extreme inside and outside and on the ...bottom. The ring, n, should be tool-steel, and may be ...olded by an expert smith, but if the smith is doubtful, ...t had better be forged without welding. When it is im...portant to maintain a standand diameter of work, a hard...ened ring, l, or, in case of lettering or ornaments, a disk ...is used. In single-acting press dies it is the die center, l, ...ather than the interior of the punch, k, which determines ...he diameter of the work. It is well to have the interior ...of the punch a close fit in work, such as can ends, where ...the edge is all drawn in, but in cases where a radial edge ...is left, such as shown in Fig. 7, the punch may be com...paratively loose. In double-acting press dies the inner ...punch determines the size and often the shape also of the ...work, while the die may not fit the work all the way but ...only at the upper corner.

In regard to foundry patterns for small die parts I have found it a matter of economy to have on hand 6 or 8 sizes of bottom-plate patterns, u, Fig. 3, well made and varnished, with core-prints and a core-box to core the slots, z, straight sided and to leave a spot, w, to finish. To this base pattern, "hurry up" pieces are added as needed for individual dies, the same base pattern being used for die Fig. 2 and die Fig. 3, with different additions and in case of Fig. 3 a central core. Die castings made from such patterns need not be machined all over.

In dies for double-acting presses, which cut the blank as well as form it, a hardened and ground ring, e, Fig. 15, is used with a steel ring, c, welded to the wrought-iron plate, b; these do the cutting, and when the corner, d, of ring, c, becomes dull it is upset by hammering on the lower face, which must then be turned up again to fit the hardened ring, e. The inside plunger, a, Fig. 15, may be made of machine steel, for working tin plate or brass; but for working steel it had better be either hardened steel or cast iron. In this particular die a little variation in the diameter of the inner punch, a, is of no consequence; if the work had been blanked out first in another die, or cut into disks in the circle shears, then this die might have been made entirely of cast iron, and would consist of only three pieces similar to the die shown in Fig. 16, with perhaps a chilled surface, g.

The die shown in Fig. 16 was made of cast iron, except the plate, l, which was of machine steel. The outer punch, i, and the die, k, were cast at a car-wheel foundry, and the working faces, j and s, were chilled very hard. This die worked well on tin plate. Another die, made of cast iron and chilled in the same way, working on black steel which had been annealed after the first operation and was rough, gave much less trouble than previous dies on the same work with hardened steel rings on the faces, although either had to be ground true and polished occasionally.

In drawing deep work, or in cases where the metal is severely worked, it is customary to anneal the work one or more times during the process, but tin plate is ruined by annealing; hence such work is drawn and annealed before plating, or, if some stiffness is required in the finished piece, one drawing operation may be performed after annealing and plating.

In cutting and forming bright steel it is customary to use oil as a lubricant and apply it in spots over the sheets before they are cut up into strips. In working tin plate the coating of tin, together with the thin film of oil left on it from tinning, are ordinarily sufficient lubrication; but in drawing large pieces in a double-acting press a stick of parafine wax may be passed once around near the edge of the blank. In working black steel plate which is to be tinned afterwards, oil is objected to by the tin-house foreman, as making him extra work, and an alkaline solution which will clean in an acid pickle is used, either soda water or a soapy water. One concern buys a soap made from fish oil, puts about a pound of this in a gallon of water and applies with a sponge to each side of the blank.

A day's work for a boy or a girl, and a press will depend upon the shape in which the stock comes to the press as well as the speed of the press and the dexterity of the operator. With a die, such as shown in Fig. 2, for cutting and forming ends, 4 ins. in diameter or smaller, from tin plate cut into strips, 20 ins. long, and wide enough for two rows of ends, an experienced operator will produce from 8,000 to 10,000 pieces in ten hours. With a similar die for making ferules for wood handles out of the scrap thrown into a pile, a boy will probably get 2,000 ferules in ten hours. A press with automatic feed, cutting bicycle chain links, will produce about 90 pieces a minute, working steel in long strips rolled up. The gang die cutting and forming can ends from sheet shown in Fig. 4, cut about 11 sheets per minute, making two strokes to a sheet, while the other gang die described cut about 20 sheets a minute, but from this some time is to be deducted for handling stock, etc. A large drawing press on work from 10 to 20 ins. diameter, and from 2 to 6 ins. deep, will produce from 3,000 to 5,000 pieces in ten hours, but if such work does not "nest" well together it may occupy so much room as to retard the work.

The length of time that a die may be used at one sharpening will depend upon conditions and may vary from half a day to two months. The material of the punch and dies, the material worked, the angle of the cutting edges, or the complement of a, Fig. 2, and the shear of the die, are the principal factors in the life of the cutting edge. I have seen dies used for ten weeks on tin plate at one sharpening. Fifty hours is about the average time in an electrical factory for dies cutting number 26 gage soft steel. Dies cutting bright soft steel for builders' hardware, from 1-16 to ⅛-in. thick, with both punch and die hardened, ran from two to four days at one grinding. Dies with square corners for cutting edges, and no shear on either punch or die, ran about half as long as dies cutting the same pieces from the same stock, with a cutting edge of about 82°, and with shear. The high and low points in the upper edge of m, Fig. 3, may be about 1-16-in. difference in height, and the angle, a, Fig. 2, from 5 to 10°.

The selection of a suitable press deserves more attention than is sometimes given to it, too small a press being liable to spring and injure the dies, while too large a press is slow and clumsy. Presses for cutting only may generally be much lighter than when used for cutting and forming combined. In a stamping factory the expense may often be greater for dies than for presses, and if a different press is more suitable, it may pay to buy it even though a first stands idle a part of the time.

The steel best adapted for sheet metal drawing is not readily distinguished from its performance in the regular tensile test, for drawing produces a different form of stress in the metal. We may represent an elementary section of a piece of sheet metal being drawn by Fig. 22, where p represents the tensile force due to the thrust of the press and c c the compression due to the wedge shape of the elementary piece and its resisting the force p. As these elementary pieces abut against each other and are all coming in together, there is comparatively little friction for the force p to overcome, and the relative magnitudes of the forces may be represented by the triangle obtained by producing the two sides of the tapering part until they intersect. From this triangle of forces we may conclude that the change of form is due to tension in one direction combined with compression of about twice the magnitude in another direction, while the force in the third direction, or that of its thickness is only nominal, or just sufficient, to keep the wrinkles from forming. As the stock pulls over the corner, bends, and straightens again, the tensile stress is thrown first to one surface and then to the other, and in this way does more stretching than it otherwise would.

Several instances have come to my notice which would indicate that the action of steel under this combined stress of tension in one direction and compression in another, is different from that under either stress taken separately.

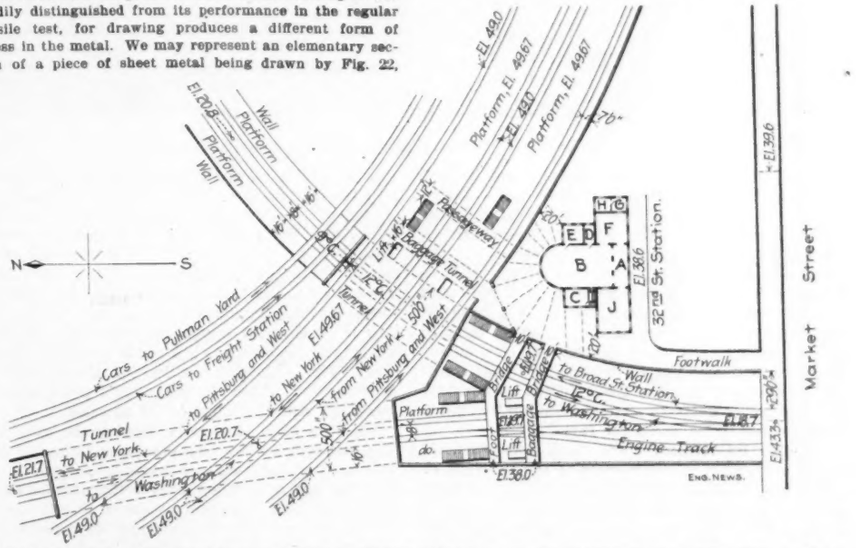
The two examples mentioned above, where a 1⅝-in. hole could not be stretched to 2 ins. without tearing, under tensile stress alone, and the wheel rim which stretched from 9-64 to 13-32-in. under a combined tensile and compressive stress, indicate something more than a variation in stock. In one case we fail to get an elongation of less than 50%, while in the other we get easily an elongation of 200%.

PASSENGER TRANSFER STATION AT PHILADELPHIA; PENNSYLVANIA R. R.

Among the extensive improvements now being carried on by the Pennsylvania R. R. to improve the terminal facilities at Philadelphia, Pa., is the rearrangement of tracks on the west side of the Schuylkill River, and the construction of a passenger station at Market and 32d Sts., near the present Powelton Ave. Station.

The object of the new work at this site is to avoid the delays which through trains incur by entering and leaving the dead-end terminal station at Broad and Market Sts., and to provide accommodation for Philadelphia passengers on these trains. Under the new arrangement, through trains on either of the two main lines will stop at this transfer station, to receive and discharge Philadelphia passengers, who will be transferred to and from the Broad St. terminal by local trains. The new arrangement has been planned by Mr. Wm. H. Brown, Chief Engineer of the Pennsylvania R. R., to whom we are indebted for the plan and other information.

There will be four new passenger tracks at the new station; two for the main line west, and two for the New York Division, leading to the Broad Street terminal; these will be elevated above the street level. There will also be two tracks for the Philadelphia, Baltimore and Washington line, located below the street level; and two tracks for through trains between New York and Washington, also below the street level. These latter tracks start on an ascending grade at the station



NEW STATION AND TRACKS OF THE PENNSYLVANIA R. R. AT MARKET AND 32D STS., PHILADELPHIA. W. H. Brown, Chief Engineer.

and join the tracks of the New York Division at a point west of the station. The relative positions of these lines will be seen from the elevations marked on the accompanying plan.

The new station is situated at the street level, or at an elevation midway between that of the high level and low level tracks. It will be a brick, stone and terra cotta building, approached by a roadway from Market St., and having a covered walk and platform in the angle between the two lines. The upper platforms will be protected by iron and steel shelter sheds. The station will have an entrance hall or vestibule, A, 11 × 35 ft.; general waiting room, B, 35 × 57 ft., with a semi-circular end of 19 ft. radius; ticket office, C, 14 × 15 ft.; parcel room, D, 8 × 14 ft.; men's toilet room, E, 14 × 17 ft., women's room, F, 23 × 25 ft.; alcove and women's toilet rooms, G and H, each 11 × 12 ft.; and a baggage room, J, 25 × 35 ft.

Two bridges, 10 ft. wide, for passengers and baggage, respectively, will serve the platforms of the two low-level lines, while two tunnels 12 and 16 ft. wide, for the same purposes, will serve the platforms of the high-level line. Four stairways 8 ft. wide, and four hydraulic baggage elevators 6 × 14 ft., will connect the platforms with the bridges and tunnels.

The contract for the station has been let to Geo. W. Roydhouse & Co., of Philadelphia, Pa. For the alteration of tracks, the contract for masonry work has been let to John Goll & Co., of Philadelphia, and that for the structural steel to the Phoenix Bridge Works, of Phoenixville, Pa.

THE UTILIZATION OF PEAT AS FUEL.

Serious attention is being given in recent years to the possibilities in the use of peat as fuel. In the North-European countries, in Ireland, and in some other regions, the peat deposits have for a long time formed an important source of fuel.

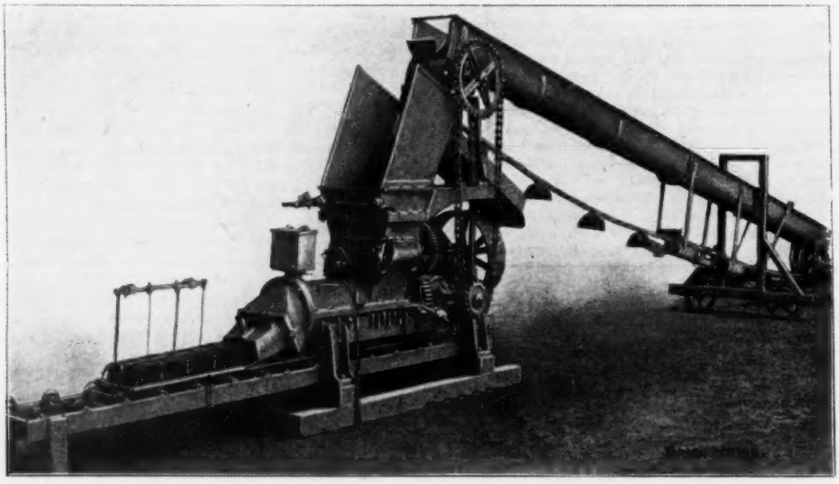


FIG. 1. RAW PEAT BRIQUETTING PRESS.

Even in Germany, which is relatively rich in coal, the peat-bogs are being exploited fairly extensively. In the United States, on account of the great abundance of coal and other fuels, there has been little inducement for the development of the country's peat wealth; nevertheless, many have believed that even at present there is a wide field for profitable use of peat-fuel in this country. Far greater possibilities in this direction exist in Canada; practically bare of coal, but rich indeed in peat (as is also the United States), that country is gradually finding itself forced to consider the use of this latter material on an extended scale to supply its needs for fuel.

Peat, in its natural state, is a poor fuel. It holds, suspended in the meshes of the network of vegetable fibers of which it is composed, a very large percentage of water, and it also contains much water in more intimate combination. The usual method of treating the peat for use as house-fuel consists of cutting blocks or "bricks" of peat from the bog and stacking them in an open pile for air-drying. When thoroughly air-dried, the peat still contains 20 to 30% of moisture, and forms a light, loosely-coherent mass. Where production on a larger scale is carried on, presses are employed to mechanically force out about half the original water contained in the peat and to compress the blocks at the same time into a material of considerably greater density. These bricks may be dried in the open or in a hot-blast drying chamber; in the former case the final moisture is about 15%, while in the latter it may be reduced to as low as 12% of the mass of the dried peat. Such prepared peat is directly available as fuel for power purposes, for domestic use, etc., but its heating value as well as its firmness and solidity are insufficient to make it a good metallurgical fuel.

A number of methods of treating peat on the above general lines have been developed, and some of them are in operation. It has long been realized, however, that the most desirable peat-product would be a coke, and numerous attempts have been made in this direction. Up to the present none of these attempts has had sufficiently practical results to make commercial working a success. A process developed quite recently promises better results; if the claims made for it are well-founded the peat-coke it produces will soon be a valuable and widely-used fuel. The process is the "Economic Carbonization Process," patented by Mr. Oscar Daube, of 309 Broadway, New York, and referred to in our issue of Jan. 9 in connection with the extensive industrial works in course of establishment at the "Soo." The Canadian rights for the process have been acquired by the Canadian Peat Products, Limited, of Brantford, Canada, who will develop the peat industry in the Dominion. It should be remarked that the process referred to is a general coking process, applicable to any carbonaceous material, wood, coal, bones, peat, etc. Its essential part is the use of a coking retort in which the heat is applied internally by means of hot, non-oxidizing gases, the products of combustion of a small furnace, and the further use of a separate cooling chamber, by means of which the working of the retort is made practically continuous. These features are the "economic" elements of the process. The application of the process to peat coking is of especial importance, because, as above stated, no process has yet made a success in this field. The following outline of the method of working for which the company's plant is being designed will therefore be of interest.

The first step, cutting or digging the peat from the bog, will be done by machines imported from Europe, where machines have long been in use for this purpose. They deliver the peat in blocks to an inclined conveyor. From the latter the blocks will go to a press of special construction, also a foreign machine which has been used in Europe for many years past, in which spiral cutters tear the peat apart, knead and press it to remove the water and produce a solid mass, and force it out of a mold or former-opening in slabs, which are then cut by knives into separate "bricks." The press is shown in Fig. 1; the feeding-in conveyor, the kneading cylinders below the hopper, and the slab of peat issuing from the former-opening upon a roller bed, can be seen in the view.

The wet peat-bricks are piled in an open pile upon low trucks, and these are run on tracks into a drying oven. This latter is a steel or brick chamber, with doors at both ends and a small heating furnace at one side. If of steel the chamber has a brick outside covering, so as to reduce the radiation. The furnace is of ordinary construction, but has a set of superheater coils arranged in the lining; through these the air is drawn to supply the fire, in order to economize fuel. The hot products of combustion are admitted into the drying chamber by a perforated pipe extending along the center, and rising through the peat bricks piled on the trucks they evaporate a large part of their moisture. An outlet at the bottom of the chamber draws off the moisture-laden air. The drying chamber is exactly similar to the coking retort, next to be described, but the temperature is kept well below the point of decomposition of the most volatile [illegible] of the peat, as the sole function of the [illegible] the removal of moisture. When the [illegible] sufficiently dry the trucks are drawn [illegible] of the chamber at the opposite door to whi[illegible] they entered, and are run forward into the re[illegible] placed just ahead of the dryer. The peat is [illegible] in the form of very hard and firm bricks; the [illegible]tained moisture is only about 8 to 10%, wh[illegible] is the limit to which the drying can be carri[illegible] without decomposition. The peat in this fo[illegible] is well adapted for use as fuel for power pur[illegible]es, etc. The process thus far is not new, and d[illegible]nds for success on (1) elimination of most of the mechanically-held moisture from the co[illegible]minuted peat, (2) compression of the latter into [illegible]rm and solid bricks, (3) thorough drying of t[illegible] bricks without decomposition. It may be noted that this drying involves a great reduction in [illegible]ume of the bricks, but unless the drying is [illegible] rapid they will have become very hard and [illegible]rm, so much so as to permit even of polishing.

It is generally advantageous to trans[illegible]rm the peat into peat-coke, which, besides being itself a more valuable product than the peat-bricks, permits the recovery of valuable by-products. The coke is produced in a retort constructed the same as the drying oven, and like it heated from within by means of highly-heated, incombustible and non-oxidizing gases produced in a separate furnace. The peat is thus distilled by the heated gases without suffering loss through burning. The coking retort is a steel chamber covered with brick to reduce radiation. The trucks on which the peat-bricks are piled are run in on tracks at one end and out at the other, tight doors being provided at both ends. A furnace furnishes highly-heated products of combustion, which enter at the floor level, and heat the peat to decomposition. The gases pass off through a pipe at the floor level and go in the usual manner to washers, condensers and gasometers. When the coking is completed the cars are drawn out quickly, in order that the retort may lose as little heat as possible, and a new charge is run in. The coke-laden trucks are run into a cooling chamber—simply a closed iron chamber—in which the coke cools off without the combustion and loss which would take place if it were allowed to cool in the air.

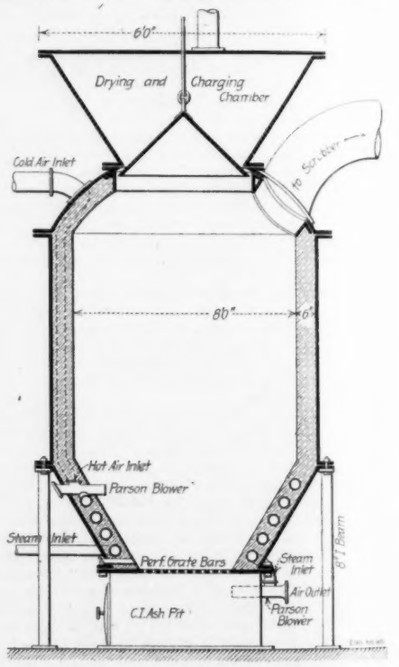


Fig. 2. Coking Retort of "Economic" Process.

The construction of the retort is illustrated in Fig. 2, which represents a small retort for making bone-charcoal by this system; a commercial peat-coking retort is exactly similar in construction, but much larger, an economical size being 100

long, and with as many longitudinal tracks as may be desired. As will be seen from the cut, the retort is of steel plate construction, the sides and ends covered with brick. The steel-plate trough seen at the top was used in the case illustrated to dry one of the by-products of the process, acetate of lime; the air space shown keeps this pan from overheating. The transverse section shows at one side the furnace which supplies the hot gases for the distillation. The furnace consists of a fire-pot, a low ash-pit, and a large combustion chamber. The side lining of the

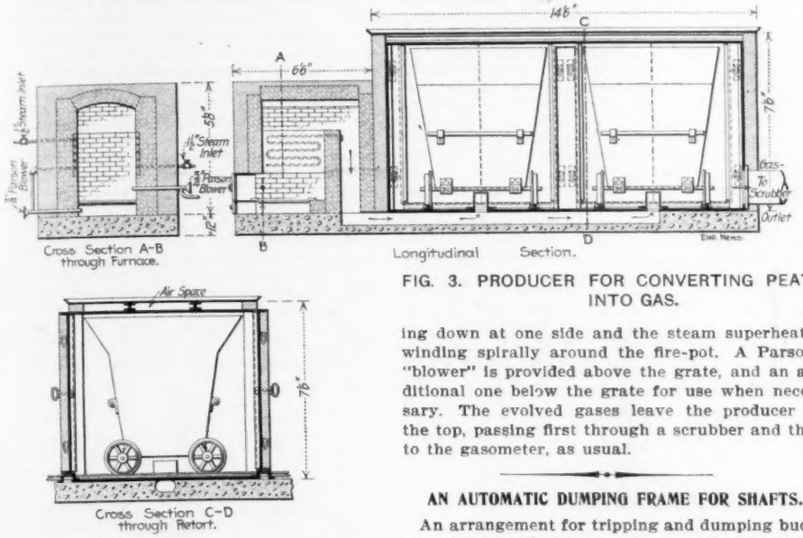


FIG. 3. PRODUCER FOR CONVERTING PEAT INTO GAS.

latter consists of thick cast-iron plates, in which a sinuous passage is cored out; these plates are superheaters, and their arrangement and use can be seen from the cross-section of the furnace. The superheater there shown at the left discharges its steam through a Parsons "blower" or steam-air injector, delivering a mixture of hot steam and air below the grate, thus supplying the necessary oxygen for combustion of the fuel on the grate; the one on the right receives its steam at the bottom and discharges it into the flue just back of the bridge-wall. This has the object of supplying additional hydrogen for the production of water gas in the retort. The inert gases of combustion from the furnace, mixed with water-vapor, pass into the retort through pipes, which in the case of a long retort are perforated on their upper surface; in the case shown they have discharge outlets directly below the centers of the trucks. Passing upward through the peat, they heat it to the point of distillation, and then with the evolved gases sink along the walls and pass out through a discharge pipe. This latter leads to a scrubber and thence to a gasometer, where the permanent combustible gases are stored for use. This portion of the process presents no novel features.

This process of coking, as explained previously, gives, by applying the heat from within the retort through the medium of inert gases, a very economical use of the applied heat. The use of separate cooling chambers makes the coking process virtually continuous, and saves the time and the heat which would be lost if the cooling were done in the retorts themselves. A uniform temperature in the retort is further obtained, resulting in uniformity of product and economy of time and heat. The temperature in the retort, it may be noted, is regulated between 550° and 650° F., while that in the drying chamber preceding the retort never exceeds 300° F.

The amounts of coke and of the various by-products obtained in the process are stated to be about as follows, per 100 lbs. of dry peat:

One lb. methyl alcohol; 2 lbs. acetic acid; 1 lb. anhydrous ammonia; 300 cu. ft. combustible gas; 6 lbs. tar; 32 lbs. coke.

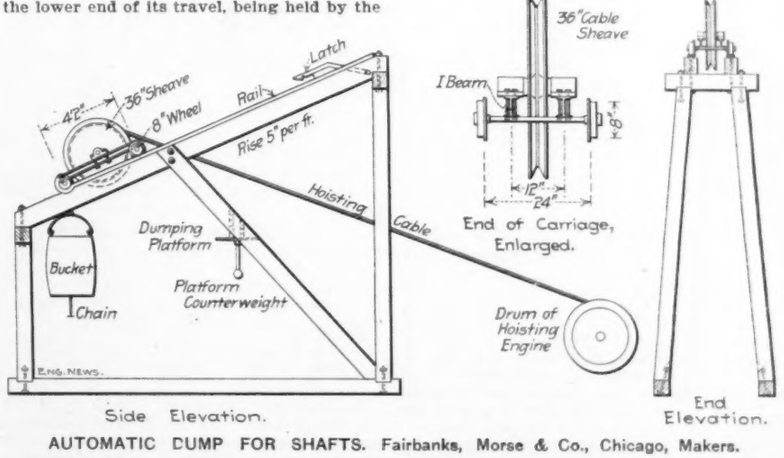
The coke produced is stated to be of high heating value, and to have a low percentage of impurities. It is as firm and solid as Connellsville coke, and perfectly adapted to blast-furnace or other metallurgical work.

A variation of the above-described method of treating peat involves the conversion of all of the peat into combustible gas by complete reduction in a gas producer. The producer for this work is illustrated in Fig. 3; it has a charging hopper, in which the peat-bricks as they come from the drier may be heated for a little further reduction of moisture before charging. The producer is lined with fire-brick, and two superheater tubes are built in the lining, the air superheater leading down at one side and the steam superheater winding spirally around the fire-pot. A Parsons "blower" is provided above the grate, and an additional one below the grate for use when necessary. The evolved gases leave the producer at the top, passing first through a scrubber and then to the gasometer, as usual.

AN AUTOMATIC DUMPING FRAME FOR SHAFTS.

An arrangement for tripping and dumping buckets at the head of tunnel, mine, and other shafts has recently been introduced for the purpose of reducing the amount of labor ordinarily required for this work. The general design is shown in the accompanying cut. Instead of the usual form of head frame with fixed sheave above the mouth of the shaft, the frame is made with inclined top timbers, the incline being 5 ins. to the foot. Upon the frame travels a steel carriage or trolley, upon which is mounted the main hoisting sheave.

While the bucket is being hoisted, the carriage is at the lower end of its travel, being held by the



AUTOMATIC DUMP FOR SHAFTS. Fairbanks, Morse & Co., Chicago, Makers.

rails, which are bent upward to form a stop. When the bucket is hoisted clear of the shaft, a stop prevents it from rising too high, but the winding of the cable still continues, and the carriage is thus hauled up the incline until it is automatically caught and held by a pair of latch bars at the head of the incline. The cable is then paid out and the bucket lowered upon a dumping platform, which has a slot to receive a loose chain attached to the bottom of the bucket and carrying a disk or ball at its end. The weight of the bucket tilts the platform, and the bucket is inverted, being held to the platform by the ball, which cannot pass through the slot. The empty bucket is then hoisted into position again, and the latches released. Then as the cable is unwound, the carriage runs back to the shaft and the bucket descends.

The operation is said to be very rapid and reliable, and is entirely controlled by the man at the hoisting engine. The apparatus can be so arranged as to dump into different pockets or bins. The plant is being introduced by Fairbanks, Morse & Co., of Chicago, and has already been installed by the Forest City mine at Leadville, Colo.; the Alcazar Mining Co., at San Antonio, N. M., and at other mines in Colorado and Arizona, where labor is scarce and expensive.

NOTES ON THE OPERATION OF CONDENSERS AND CONDENSING ENGINES.*

By Alex. Dow, M. Am. Inst. Elec. E.†

COOLING TOWERS.—During the past year we have had a little more experience with cooling-tower fans. We have found that a curved blade, or so-called helical fan, in a cylindrical draft tube has less backlash than a straight-blade fan, but is not by any means free from backlash. We put a new helical fan in the draft tube of our Worthington tower and rid ourselves of the trouble we had had with icicles by putting a steam jacket around the outside of the tube. The zone of reversed draft is appreciably narrower than it was when we used the straight-blade fan; but the reversed draft is still there. As between fan draft and natural draft, our observations tend to show that natural draft is no cheaper in first cost than is fan draft for the same final water temperature.

If you are going to cool the water with natural draft, you will need so much more tower to get a given temperature that you will more than offset the additional cost of the fan and its driving apparatus. Whether the natural draft will be the cheaper to operate depends on how much the power for auxiliaries and the power from main engines are relatively worth to you. It is very likely that your figures will come out even for either style of tower. The fault of the natural draft tower is that you don't get a good draft until you have a bad vacuum. The draft depends on the water being heated enough to raise the temperature inside the tower above the temperature of the atmosphere. The difference of temperature necessary for a sufficient draft during most of the year is such as is only obtained when the circulating water is heated by exhaust steam of temperatures correspondingly to relatively poor vacuums. In our electric light business we have the advantage that our heavy loads come at night and in the winter time, when the lower temperature of the external air permits good draft simultaneously with comparatively good vacuum.

Appreciation of this characteristic of natural-draft towers has led to the production of some towers which are not enclosed at all, and to the evaporating surfaces of which the air has access from all sides, so that there is no regular draft at all. I have a report from the operation of these towers, but have no personal knowledge thereof. It is hardly fair to call this device a tower. It is a stack of mats or similar cooling surface, and I would suggest that the proper name for it is "cooling stack."

The home-made natural draft cooling tower at our Foundry St. station‡ has been in operation during the entire 12 months. It is a commercial success. It was designed for aproximately 500 engine HP. on a 20 lbs. per HP. rating—that is to say, to take care of 10,000 lbs. of steam per hour. To that extent it is a technical

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‡See an article by J. R. Bibbins in Engineering News, March 20, 1902.

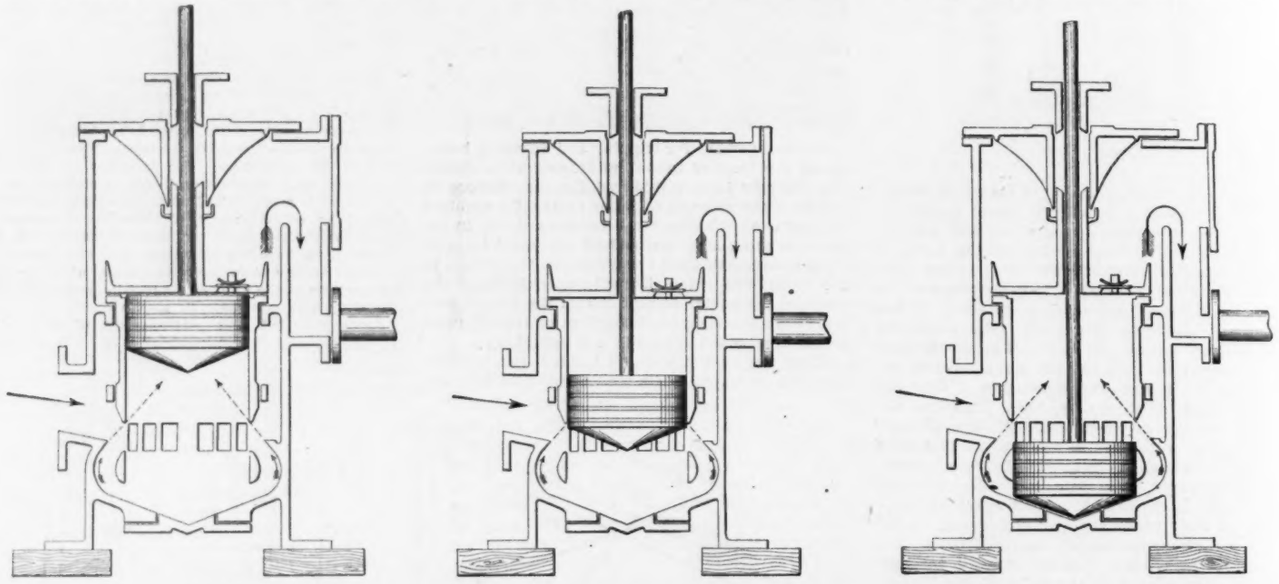
success. We have, however, acquired the habit of working it in the evening at about twice that duty. The surface condenser with which it is associated was furnished several years ago by Messrs. Worthington as an 800-HP. condenser on a 20-lb. rating. It is of the Admiralty type, and has 1,600 sq. ft. of tube surface. Our latest test was a 24-hour test, made by the engineering department of the University of Michigan. Of the results of this test only a few figures are of immediate interest. One fact, which was well brought out, is that the vaporization in the cooling tower is practically equal to the condensation. In this case it is in excess by 1.01% only. To generalize this statement, it means that for every pound of steam reduced to water in the condensing system a pound of circulating water was evaporated in the cooling tower. This particular 24-hour test is merely a good illustration of a general rule; for all the cooling tower experience of which I have knowledge is that the amount of make-up water required by the tower is practically identical with the amount of condensation furnished by the engines. One would anticipate that there would be an excess of condensation because, while we recognize that the cooling of the water in the tower is chiefly by evaporation, there must be some cooling by the transfer of heat frdm the water to the air. Considering the specific heat of air, it becomes obvious that this transfer is negligibly small in comparison to the heat required by vaporization of water, and we are justified in saying that the function of the air passing through a cooling tower is not to cool the water by contact, but merely to sweep out the vapor given off by the water.

Another interesting observation is that the water circulated per hour, during the 24 hours, was on the average 50 times the weight of the steam condensed. The average observed temperature, and from the observed temperature of the steam entering the condenser. According to these calculations the circulating water only accounts for 80% of the heat of the steam. The experts concluded that the remaining heat was lost by radiation. There are circumstances which make it likely that there was, in this case, a considerable amount of condensation due virtually to radiation. The temperature of the house was 61° F. The exhaust pipe from the engines to the condenser is comparatively long, and located in a relatively cool portion of the house. The temperature of the steam entering the condenser averaged 134° F. It was considerably higher during some portions of the day. There would, therefore, be an appreciable loss by radiation from the long exhaust pipe and from the walls of the condenser. Moreover, observations taken at other times, and for another purpose, show that in the exhaust pipe there is always water traveling with the steam toward the condenser. The two engines which exhaust into the condensing system have their exhaust valves in the bottom of the cylinder ends, and these valves open in such a manner that any condensation lying in the cylinder at the moment of release will be swept out without having a chance to re-evaporate.

Apropos of this observation, let me remind you that this location of exhaust valves is recognized as being important to engine economy, and that its assistance to that end is admittedly due to this instantaneous sweeping out of all condensation from the cylinder. The water which we find traveling in our long exhaust pipe is, therefore, initially (and I think, mainly) that resulting from cylinder condensation; to which is added the condensation due to radiation from the pipe. While, therefore, I question the value of 20% figured in this particular test, I am satisfied that this condenser receives a considerable proportion of the discharge of the engines, not in the form of steam, as is usually assumed, but in the form of entrained water. It follows that the common recommendation that the condenser should be set as near as may be to the engine which it serves, in order that the full working value of the vacuum may be obtained, should be revised to stand something like this: The passage of steam from the engine to the condenser should be accomplished with a minimum loss of pressure—that is to say, with a minimum friction. Pipes leading from an engine to a distant condenser should be recognized as cooling surface and given every opportunity to radiate heat.

AIR IN CONDENSING SYSTEM.—In our discussion last year Prof. M. E. Cooley pointed out that the pressure is a surface condenser is the sum of the pressures of all the vapors contained therein, and that the difference between the observed pressure and the steam pressure corresponding to the temperature is an evidence and a measure of the non-condensible vapor, presumably air, which is mixed with the steam. My observation is that this difference may be as much as 2 lbs. absolute pressure —that is to say, that the temperature of the vapor in the condenser may be about 126° F., corresponding to an absolute pressure of 2 lbs., while the observed vacuum is equivalent to an absolute pressure of 4 lbs. The vapor pressures in the condenser, then, are 2 lbs. steam pressure and 2 lbs. air pressure; total, 4 lbs. The presence of this air means, of course, a 2-lb. reduction of the mean effective pressure in the low-pressure cylinder of the engine. Another common evidence of the presence of air along with steam is that a heater in which the pressure is maintained at a point above atmospheric pressure, so that no air can enter from the outside, which is not provided with a thorough circulation of steam, nevertheless becomes air-bound. This air or other gas unquestionably enters the steam system dissolved in or entrained with the feed water. This is well known in live steam purifier practice that provision is always made for the circulation of steam through the purifier, either by means of a pipe leading back to the steam main at a point where the pressure is lower, or by taking from the top of the purifier the steam necessary to drive the feed pumps or some other auxiliary. The air or non-condensible vapor passes to the top of the purifier and is worked through the cylinders of a non-condensing engine along with the steam quite satisfactorily. It is only when an attempt is made to condense it that it proves troublesome. In a condensing plant, therefore, when live steam purifiers are used, it is desirable that the purifier circulation be obtained by piping to a small non-condensing auxiliary which will discharge the non-condensible vapors outside of the condensing system.

In feed-water heaters there is also a choice between closed and open heaters. When a heater is interpolated in the main steam pipe between the engine and the condenser, of course, it must be closed; but the heater which receives the steam from the auxiliaries should be an open heater with a well-arranged vent system. Up to the point where the water is raised to boiling temperature the auxiliaries may be profitably run non-condensing; the obvious profit being the absorption of the heat of the auxiliary exhaust steam by the feed water; and the less apparent profit being the release from the feed water of all non-condensible vapor which can be driven off by the application of heat up to the temperature obtained in the heater.



Plunger at Top of Stroke. Plunger at Middle of Stroke. Plunger at Bottom of Stroke.

DIAGRAMMATIC SECTIONS OF EDWARDS PUMP, ILLUSTRATING ITS OPERATION.

When feed water is taken from the hot well or from the circulating system it should be taken at a point where the entrainment of air is a minimum. It is frequently taken from a surge tank in which the water is much aerated by splashing. If this aerated water goes to a vented open heater, in which it has an opportunity to stand after being heated, this air will be got rid of. If, however, it is pumped directly through a closed heater to the boilers, the aeration will not be got rid of and will inevitably reduce the vacuum in the condenser.

CONDENSER AIR PUMPS.—The air that gets past the heater and purifier and goes through the engines has finally to be removed from the condenser. When a contracted throat condenser, such as the Bulkley or Worthington cone, is used it is assumed that the air will be entrained by the falling injection water and swept through the throat and down the tail pipe. With the Weiss countercurrent condenser, in which the top chamber is essentially a spray chamber and there is no contraction of the discharge pipe, a dry vacuum pump is always made a part of the system. The first instance in my knowledge of the dry vacuum pump being used with a steam engine condenser was in a Worthington plant, but I think we may credit the Weiss people with educating designers into the present common practice of making that kind of pump part of the equipment of every large barometric condenser. Its addition to such a condenser makes the

hourly values are 293,536 lbs. of circulating water and 5,910.6 lbs. of steam. This is not to be understood as meaning that we had any such quantity of water available for circulation as is figured. In common practice one does not use any more water in a cooling tower than is necessary to keep the circulating system filled. Some excess of water is convenient, and this can lie in the bottom of the tower or (when the tower is built on the ground level) in a tank underneath the tower. In this case the water in the system goes round about once in 10 mins. The reserve is larger than usual, being intended to act as a reserve supply of feed water.

CONDENSER PIPING.—The heat balance which was got out by the gentlemen from the University of Michigan states that during this particular test the exhaust-steam system lost about 20% of its heat by radiation. Let me make this statement clear before commenting on it. The quantity of circulating water was figured by counting the strokes of the pump. There is probably some error in this, as the pistons do not travel exactly the same distance at every stroke; but the value, I think, is not very far wrong. The condensation discharged from the condenser was accurately weighed. The temperature of the circulating water was taken as it entered the condenser and as it left the condenser. From the quantity of the circulating water and the differences of temperature, the heat units delivered to the circulating water were calculated. The heat units given up by the steam were calculated from the known weight of the condensation and its

operation much more convenient and reliable. I expect to see this custom extended to all large jet condenser equipments. In surface condenser practice, however, the tendency, as I noted last year, is toward the adoption of the vertical, single-acting type of pump which, when properly designed, disposes of the air accumulating in the surface condenser in a very satisfactory manner.

The new air pump, which we expected to install last year, is of the vertical type and known as the Edwards pump. It is not new in British practice. It is, in fact, being rapidly recognized as the standard on that side of the water. I have known of it for over two years, and when I learned that the Wheeler Condenser Co. had arranged to manufacture an Edwards pump on this side of the water, I lost no time in placing an order. The accompanying drawings illustrate the action of the pump. You notice that it is single acting. Usually there are two or three pump cylinders driven from cranks on the same shaft, so that the pumping is continuous; but each of these cylinders is an independent pump. The piston is flat on the top and conical on the bottom. The bottom of the pump cylinder, also, is coned to receive the piston on the downward stroke.

The pump being crank-driven, clearances can be made exceedingly small. Minimum clearance on top of the piston is of great importance. Consider the action of the pump if it is handling only air. On the down stroke it receives its charge through the ports in the sides of the cylinder which the piston uncovers as it reaches the bottom of its stroke. On the up-stroke the air above the piston, which was received at the pressure existing in the condenser, is compressed until its pressure is higher than that of the atmosphere to an amount sufficient to lift the valves. If there is no clearance, the entire charge of compressed air is expelled. If there is any clearance, that clearance remains filled with air at atmospheric pressure and its contents expand again as the pump makes the return stroke.

Consider, further, the effect of clearance when the discharge is partly water. In this particular pump the water remains below the air, and if there is enough water to fill the clearance space there will be no air left in the pump to expand during the return stroke. In many pumps, however, the interior arrangements are such that there are pockets which remain filled with air. The pump must discharge not only against atmospheric pressure, but against the head of water lying on top of the valves. In the case of the steamer "Tashmoo," recently described to us by Mr. A. G. Mattsson, this back pressure is that due to a column of water of several feet, which is used to supply the trimming tanks. In such a case any air pocketed is compressed considerably above atmospheric pressure, and expands afterward with increased detriment to the vacuum. In the Edwards pump a very small amount of water is retained on top of the valves, the dam shown on the drawing fixing the height at about 4 ins. of water. Moreover, as it is a crank-driven pump, the pause of the piston at the end of the stroke allows the valves to seat themselves before the return stroke is started and there is no back flow of water.

The action of the piston at the bottom of the stroke deserves special attention. You will notice that water and air entering the pump together are allowed at once to separate. The water gravitates into the conical bottom, while the air ascends into the annular chamber from which the ports open into the cylinder. When the piston comes down it strikes the water sharply, splashing it outward and upward. The form of the annular chamber is such that the water is thrown back into the cylinder through the ports and well up ahead of the piston. The air passes into the cylinder before the water, and as soon as the ports open; because the downward motion has produced a very good vacuum above the piston. The water is splashed and driven around after the air and is caught by the piston on the return stroke and carried upward on top of the piston and below the air. The air is discharged first and the clearance retains water only.

The distinguishing peculiarities of this pump are the absence of foot valves, and the manner in which the water is driven by impact into the pump chamber. There being no foot valves, the pump chamber is in perfectly free communication with the condenser at the proper moment, and the entire difference of pressure between the pump and the condenser acts to deliver water and vapor to the pump, none of it being required to raise intervening valves. In these respects it is superior to other good vertical pumps, while it retains the general good qualities of the vertical single-acting type; and, therefore, I believe it is the best air pump on the market to-day.

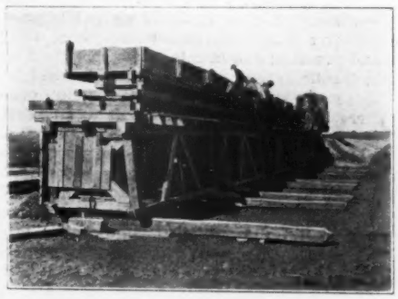
A METHOD OF BANK CONSTRUCTION BY DUMPING FROM MOVABLE TRESTLES.

By Joseph Wright, C. E.*

In Engineering News of Jan. 16, 1902, there is an interesting article describing a novel method of bank construction used by Mr. Boedker on the Iowa Division of the C., B. & Q. R. R. This article and the recent discussion of the best methods of bank construction by the American Railway Engineering & Maintenance-of-Way Association leads me to believe that perhaps a method recently used by me in bank construction on the Illinois & Mississippi Canal may be of some interest to your readers.

Having about 7,500 ft. of bank of nearly uniform height to build, and wishing to obviate the laborious work of track-raising of the common methods, and, at the same time, to leave no timber in the completed bank, I was led to the design of the movable trestle-work shown by the accompanying illustrations. These illustration show a series of self-contained sections of trestle coupled together by short sections of rails spanning the intermediate spaces and each section resting upon transverse skids. It will also be observed that the side on which the earth is dumped is boarded up, and that the space between successive sections is covered by a hanging door to prevent the earth from running in between them, and thus interfere with the free movement of the trestles towards the outer slope stakes.

The method of operation was to place the trestles sufficiently near the inner slope stakes to permit the inner slope of the bank to be built up, and then the bank was widened by moving the trestles toward the outer slope stakes until the bank was sufficiently wide to receive a track. This was easily accomplished by the small force of men necessary to dump the cars, since the pressure of the earth of itself was frequently sufficient to move the trestles on the skids. The short sections of rail forming the coupling had slotted holes for fish-plates in order to permit of a limited sidewise movement of each section independent of the others without the necessity of uncoupling. When the bank was sufficiently wide to receive a track the trestle sections were uncoupled, moved outward sufficiently to clear the bank and hauled ahead, by means of a line and a pair of single blocks, into position for the next section of bank. It was found that one team could easily move a 17-ft. section by this means, and that but little time was consumed in getting them into position. While the trestles were being moved ahead and the track was being laid on the new section of bank by a small track gang the cars were dumped on the outer slope of the bank behind, where the bank had been left unfinished, or from similar trestle work on the opposite bank of the canal.



View Showing Side Toward Outer Slope Stake.

View Showing Side on Which Earth is Dumped.

VIEWS SHOWING METHOD OF EMBANKMENT CONSTRUCTION FROM MOVABLE TRESTLES, ILLINOIS & MISSISSIPPI CANAL.

Small 1½ cu. yd. side-dump cars were used in this work, but larger cars might have been used. The total length of trestle work was sufficient to receive the entire train of cars without the locomotive, and was made an exact multiple of rail lengths to obviate the necessity of cutting rails when coupled onto the track laid on the new bank behind. The bank built was almost uniformly 6½ ft. high and 8 ft. wide on top, with slopes of 2 on 1.

Engineers will readily understand that the method used was adopted to meet special conditions, and that the great length of bank of nearly uniform height and almost level base was favorable to the method, but it is believed that the principle involved, with modifications to meet special conditions, might be used successfully in many other cases.

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EGYPT FIFTY YEARS HENCE.

In a late address delivered at a meeting of the Khedivial Geographical Society, at Cairo, Mr. W. Willcocks, C. M., M. I. C. E. and late Director-General of Reservoirs in Egypt, drew a picture of Egypt as it should be fifty years from now, when all the contemplated projects for irrigation had been completed. But he first sounded a note of warning: the modern system of perennial irrigation, once perfected, could only flourish so long as peace reigned in the country. The ancient basin irrigation depended entirely on the flood waters of the great Abyssian rivers, which no engineering effort could turn out of the Nile Valley; but perennial irrigation would be chiefly dependent on the reservoirs and dams created in the equatorial regions of Africa, and these could be shut off by an enemy for months, or even years, by damming their rocky outlets, and the Nile, deprived of this supply, would dwindle into an insignificant stream. It is for this reason, says Mr. Willcocks, that the $500,000,000 which Egypt owes Europe is in one sense a blessing, for it tends to insure against interference with the waters that give Egypt life.

But, all else being equal, the speaker saw, 50 years hence, communication by steam the whole length of the Nile. By steamer and by rail it will be possible to proceed from Alexandria and Port Said to Mombassa, or even to the Cape of Good Hope. The waters of the Nile itself, which are now in great part lost in the greatest and most terrible marshes in the world, will flow through well arranged and well regulated channels. Proceeding down the valley, the first great work will be at the Ripon Falls, where the Nile leaves Victoria Nyanza; below the Albert Nyanza, at Fobongo, will be the great regulating weir of the Nile, and from Lado to Khartoum will be one unbroken stream of pure water, and Khartoum will be an important city and the terminus of railways leading to Wadi Halfa, Sennaar and Suakin. The Blue Nile, traversing rich plains that only need irrigation to make them as productive as the Punjab of India is now, will then be harnessed, and irrigation canals led through the Peninsulas of Meroe and Sennaar will convert this now arid region into a prosperous country.

In Lower Egypt all will be changed; more and better cotton will be raised, the tobacco will be of high grade, the date palm will multiply, sugar factories will increase, and even the desert will smile. The low swamp lands between Alexandria and Port Said will again be under cultivation, as in Ptolemaic and Roman times, and Lake Aboukir will be converted into 30,000 acres of fertile land.

Mr. Willcocks, however, places the sanitation of Cairo above all else; he hopes that he sees—at the end of the next half century—the filthy Bulak quarter, that now lies between Cairo and the N. W. wind, taken in hand and purified, and Cairo itself provided with sewers, suited to Cairo rather than to Berlin or Edinburg, and the abominations of that city cleaned up. In conclusion, the speaker pointed out that irrigation, once created and maintained, a teeming population and a great empire in the Nile Valley and the restoration of these works on modern lines will enable that country to regain her lost prestige.

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ADVERTISING RATES: 20 *cents a line. "Want" and "For Sale" notices, special rates, see page XXIV-XXIX. New copy for standing advertisements should be received one week in advance of publication; new advertisements, Monday morning. The pages containing "Want," "For Sale" and "Proposal" advertisements are held open until Wednesday noon.*

As many of our readers will remember, when the Park Ave. tunnel disaster, in New York city, was under discussion, some months ago, we strongly opposed the idea so generally put forward that the adoption of electric motive power was a panacea for all ills and a sure guarantee of safety. We then declared that unless the electric installation was largely in advance of present practice, new dangers might be introduced worse than those connected with the use of steam locomotives.

Two excellent illustrations of the accidents to which electric trains are subject were furnished recently by accidents which happened within eight days of each other, one on May 29, on a car of the Northwestern Elevated Ry. in Chicago, the other on June 6 on one of the newly equipped electric trains of the Manhattan Elevated R. R. in New York city. The first of these was briefly noted in our last issue. It appears to have been caused by the burning out of a motor, which set fire to the woodwork of the car floor and scorched several passengers who attempted escape from windows in the panic which followed.

In New York a fuse blew out on a Third Ave. electric train, and while the car was not set on fire a panic ensued in which a score of people were more or less injured. Had either of these accidents occurred in a tunnel the consequences might well have been very much more serious.

With such accidents as these occurring, and with the astonishing record of accidents of all sorts which the electric railways are now rolling up, it is absurd to claim that electric traction should be substituted for steam traction because it is safer. It will be time enough to bring forward that argument when some evidence of the alleged greater safety is forthcoming.

On the other hand, we are by no means arguing against the use of electric traction. The substitution of electric for locomotive traction in all city railway passenger service, whether on the street surface, on elevated structures or in subways, is bound to be accomplished; and it is the electrical engineers' business to reduce the dangers which at present exist. The necessity for fireproof cars is already admitted by those proposing to use electric traction in tunnel service, and improvement in fusing devices is likewise needed. A safety apparatus which operates with such an explosion and volume of flame as to start a dangerous panic is certainly very far from perfection.

The hydraulic air compressing plant described by its constructing engineer on another page of this issue, is interesting as the largest application of this peculiar system of air compression which has ever been undertaken as well as for special features in connection with the design of the dam constructed to develop the power.

As stated in the article, two plants have recently been built in Canada on the same system, and a full account of them with results of tests was given in our issue of Sept. 10, 1899. In all these recent installations, the system has been called the Taylor system. It seems proper at this time to call attention to the fact that Mr. J. P. Frizell, M. Am. Soc. C. E., invented and patented this system of air compression nearly a quarter of a century ago and described it in an article contributed to Engineering News and published in our issues of Oct. 31, Nov. 7 and Nov. 14, 1878. Again, in our issue of June 8, 1893, we published an exhaustive paper on the air lift pump, its theory and practice; and in this article described also the hydraulic system of air compression which is actually the reverse of the air lift pump operation. Here again we gave full credit to Mr. Frizell as the inventor of the system, and published a communication from him giving an account of the invention of the system and the details of tests made. Of course Mr. Frizell's patent of 1878 has now expired and he has no commercial interest in the invention, which is now public property. Nevertheless, it is but just that due credit should be publicly awarded to him as the original inventor even though its commercial application comes too late for him to reap any benefit.

The two very disastrous coal mine explosions which occurred almost simultaneously recently, and each of which caused the loss of considerably over 100 lives, deserve more attention than they have received. As our readers may remember, the first occurred near Coal Creek, Tenn., May 19, and the second only three days later, at Fernie, B. C. Concerning the first of these, we have no information as to its cause, further than the statement that the mine's ventilation had been criticised by the State mine inspector before the disaster. From the Fernie disaster, however, we have direct information furnished to us by a correspondent on the spot; and there seems to be no doubt that the blotting out of 128 lives was due to a dust explosion. That such a disaster should be possible at this day, when the dangers of dusty mines are well known and have been recognized by repeated legislative acts requiring precautions for the prevention of dust explosions, seems well-nigh incomprehensible.

We have before us the testimony given at the coroner's inquest by an experienced miner, who worked in the mine where the explosion occurred up to the day of the disaster. It appears from this testimony that the roadways and galleries of the whole mine were covered with dust. The witness had seen dust 6 ins. to 18 ins. deep at the side of the main roadway, and had never seen any attempt made to remove or wet it down, except on one occasion a few days before the explosion, when some dust near the hoist was cleared away. He used coal dust to tamp his holes, as no clay was furnished and fires following the blasting were of daily occurrence. One such fire, occurring only a short time before the explosion, took half an hour to extinguish. He was in the habit of wetting down the dust for a distance of 10 or 12 ft. before firing a blast, but this appears to have been merely a personal precaution and not one which the coal mine managers either required or enforced.

To operate a coal mine under such conditions is about on a basis with running a powder mill and permitting employees to smoke while on duty. In either case, it is possible to go on for some time without disaster, but a calamitous explosion is due sooner or later.

CONCERNING STRIKES.

To the engineer it is a truism that coal is the foundation of modern industry. Stop the mining of coal and as fast as accumulated supplies are used up the wheels of commerce and to a large extent of production must one after the other come to a stop. No one can fully realize what this would mean or how far-reaching would be the distress and starvation which would result. We are being uncomfortably reminded, however, in these days that just such a condition as this would soon be brought about if only the labor organizations among the coal miners were powerful enough. The entire supply of anthracite has been suspended now for several weeks, and the Union has succeeeded in shutting up a considerable number of bituminous mines in West Virginia, besides. Many towns and cities in the anthracite region are already in sore straits for lack of fuel and the trouble is certain to rapidly spread as available supplies are used up and the demand becomes more pressing. All this because labor and capital can't agree on a division of the profits.

We all know, of course, that the interests of labor and capital are identical. Everybody who comes forward with a new plan for settling trade disputes announces this as an original discovery. So are the interests of partners in a business identical, and yet could we expect anything but controversy and deadlock between two partners in a firm if there were no basis mutually agreed upon between them for the division of profits?

Strikes have been a serious enough evil in the past, before the era of consolidations and "community of interests," but we see no escape from the conclusion that they are to be far more serious in their effect upon the general public in the future. Formerly when one concern was tied up by a strike, the public could supply itself elsewhere, and the chief sufferers from the strike were the strikers and their employers. Now, however, under the new organization of industry which the philanthropic trust promoters have bestowed on the nation, a strike means the stoppage of an entire industry. One big syndicate controls the anthracite coal mines and one big union controls the mine labor—with which union, it may be remarked, all other labor organizations are more or less in sympathy.

A few months ago we heard much of the beauties of "collective bargaining" as a solution of our labor problems. Instead of having a multitude of employers each dealing with their individual employees, we would have representives of the whole trade, employers on the one side and employees on the other, who should come together and agree on a basis of wages. Well, the present situation in the anthracite industry is an example of "collective bargaining." The miners' representatives named the conditions that labor demanded; the representatives of capital refused to accept them, and so the industry came to a standstill. Evidently the "collective bargaining" which does not result in a bargain leaves much to be desired from the standpoint of the public interest.

Who is right in the controversy? The miners or their employers? We do not know, and we doubt if any one is wise enough to answer. In order to answer this we must answer the question whether the miners are receiving fair wages, and that brings up the question, what are fair wages? The best answer to this question we know of is that fair wages are such wages as free competition in the purchase and sale of labor would fix. The unions, however, prevent free competition in the labor market. Of course they are wrong in this just as the mining companies are wrong in

eliminating competition in the sale of anthracite and just as the coal-carrying railways have for many years been wrong in fixing exorbitant rates for its carriage.

To be fair, too, we must remember that it was the anthracite mine managers who sowed the wind and now reap the whirlwind in consequence. They it was who years ago intentionally overstocked the labor market in the anthracite fields with importations of Slavs and Poles and Huns and Italians. Wages fixed by such a process are not "fair wages," and the Miners' Union was bred by such acts on the part of the mine owners.

Doubtless the trade union leaders would object to our statement that fair wages are and can only be such wages as free competition would fix. Yet when we attempt to set any other standard as the basis for fixing wages we are at once in a quagmire of difficulties. Indeed, we may go further, and say that when "union wages," so called, are set at a higher standard than this, they result in the long run to the disadvantage of labor as a whole. The union workman sees the higher wages which he receives; but he fails to understand how the volume of demand and of production is cut down by the higher labor cost and how in consequence some have to go idle who otherwise would be employed. The union workman sees the condition of these men and feels doubly assured that his only salvation is in the union; but he fails to see that if the volume of production were great enough to give work to these men, too, there would be no such difference between their condition and his as now exists, and the demand for labor would raise the rate of wages by a natural process.

Of course, we fully recognize the difficulty of relying on competition alone to fix the wages of labor. There is always danger, as every fair-minded person must admit, that the purchaser of labor will take advantage of the laborer's necessity to force wages down. This is just as wrong and indefensible as it is for the laborer to take advantage of the employer's necessity to force wages up. Judged from this standpoint, neither side to the present controversy can be found free from blame.

We are aware that other standards than the competitive have been proposed for fixing the wages of labor. Very much has been heard of the so-called "living wage" as a minimum standard. We have never yet, however, heard of any one wise enough to fix a "living wage." To do that one must fix a standard of living, and any such wage must vary with variations in the prices of the necessaries of life. This much of good, however, may come from promotion of the "living wage" idea. It may help to teach the public that wages and income are really measured, not by dollars and cents; but by what they will purchase. The trust that raises prices for its product above the point that free competition would fix—and whether it be a labor trust or a Wall Street controlled trust, makes no difference—is thereby lowering wages to the thousands or millions who have, directly or indirectly, to purchase that product.

We argue thus for the principle of free competition in full recognition of the fact that under present day conditions there are many fields in which free competition is no longer a possibility. Railway transportation, the telegraph, the telephone, and the supply of gas, water and other conveniences in cities are familiar examples of these. In such industries the state must either exercise supervision or else undertake the work itself. In no other way can the public be assured of fair treatment. Even here, however, we must still adhere to the competitive principle as the only equitable standard. That is to say, we must fix the returns on capital invested in such enterprises on the basis of the returns which competition fixes as the market rate of interest on such investments. Wages should be fixed likewise on the basis of free competition in the labor market, and any margin of profit which the industry shows should be returned to the public in the shape of reduced rates or payments for charter privileges.

We are well aware that the policy we are advocating is not a popular or usual one. The mine owners and their supporters are anxious to force the mine workers back to the competitive basis, by importing non-union labor to compete with them; but they would be very loth, we are sure, to take their own medicine and accept the competitive basis themselves. So, too, the supporters of the union are chiefly concerned to prevent competition in the labor market, by fair means or foul, to rule or ruin, without a thought of the widespread distress and disaster and destruction of life and property that follows their acts.

Nor is this evil condition confined to the anthracite field. In hundreds and in thousands of industries competition is being wiped out and prices and profits are being raised, while the workers in every branch seek to stem the reduction of wages which increased cost of living involves by demanding higher wages through their unions.

Such an organization of industry is economically unsound. It enriches the few at the expense of the many. It is constantly productive of industrial warfare, of riot, arson, murder and anarchy. The coal strike may and probably will be compromised eventually, and a temporary peace will be effected between the contending parties as has been done before. We shall see no permanent betterment, however, and no real relief from the economic evils that now loom so portentous on the horizon until both labor and capital are brought back to a sound economic basis.

LETTERS TO THE EDITOR.

The Adding Machine vs. the Planimeter for Engineering Computations.

Sir: If Mr. Whinery or any readers of his letter on adding up earthwork quantities with a comptometer, in your paper of May 29, will look up the "Journal of the Franklin Institute" for April, 1874, or Engineering News for Sept. 19, 1878, or a Buff & Berger "Instructions for the Use of the Planimeter," he will find an article by the present writer, on the use of the planimeter for not only adding up quantities, but for doing the whole thing by machinery—getting the cross-section areas, multiplying them by the proper factors, adding up and obtaining the total yardage, all at one operation.

"2 Wall St."

New York, May 29, 1902.

Using the Run of the Crusher for Macadamizing.

Sir: One of your correspondents invites discussion as to the advisability of using the run of the crusher for macadam purposes. In my estimation there is at least one decided advantage in screening the stone so as to separate all stuff under half an inch in diameter. As the stone falls into the bins from the elevator, the larger stones roll to the outer edges of the pile, while the "screenings" and fine stones collect immediately below the delivery chute of the elevator, thus producing a separation into sizes. But a separation in this way is objectionable, as one wagon load may be all coarse stone at one end and fine stone at the other.

This is not "theory," for I have seen it occur many times. The result is that when the stone is dumped upon the road there will be an excess of binding material in one place and a deficiency in another. Screening therefore seems to me necessary if for no other reason than to secure an even distribution of "binder." Furthermore there is little if anything to be saved in cost by omitting screening. Just how much more coal is consumed in running a rotary screen I do not know, but it is slight; and it must be borne in mind that a rotary screen having a slope of about 1 in 12 acts as a conveyor to distribute the stone horizontally in the bins and were it omitted some other kind of a conveyor would have to be substituted.

It is argued by some engineers that the surface coat of macadam should be of small stone of uniform size if uniform wear is to be secured, and this is undoubtedly true of trap and other very hard stone. Upon the whole, therefore, since little is to be saved by omission of screening, it seems advisable to require screening of stone for macadam to insure evenness of distribution of the "binder" and evenness of wear of the top coat.

Yours truly, H. P. Gillette.

791 Powers Block, Rochester, N. Y., June 2, 1902.

Locating a Curve to Pass Through Two Fixed Points.

Sir: I beg leave to refer to the solutions of Mr. Layfield's problem, offered in your last issue, and to say that while I hit on the same practical expedient of putting 30° in the first branch of the curve, this is merely taking advantage of an accidental and rather obvious relation. If the data were different, the result would not be so satisfactory, as in case the distance given as 275 were 375. The fact is, there is only one angle and one radius that will satisfy the conditions, and 30° is not precisely that angle.

This can be proven. Having found the radius and the centers on the supposition that the angle referred to is 30°, if the value of that radius be checked by solving the right-angled triangle formed by half the chord that lies between the given points, and the perpendicular drawn from the middle point of that chord to the center of the central curve, determined as above supposed, a discrepancy will be developed, showing that the curve does not pass through the given points. Of course, the correct center lies somewhere on the perpendicular mentioned, and the angles are correlative to its position; but an infinite number of curves can be drawn through the given two points, while only one of them will satisfy the conditions of the problem.

To assume the angle in the first branch of the reverse curve is one way of approximating a result; to assume some other unknown quantity is another; while a good drawing to scale would probably be more expeditious than either, and the foundation of both.

Mr. Layfield seemed to be bidding for a general solution, which I am unable to offer. The question is, are the co-ordinate relations of the two points in the required curve, to the given points in the straight line, sufficient to yield analytically a value, free from unknown quantities, either for the amount of curvature or the radius required?

Yours truly, Edwin E. Woodman.

Secy's Office, C., St. P., M. & O. Ry.,
St. Paul, Minn., June 2, 1902.

The Length of a Vara—Ask Questions.

Sir: Having spent the greater part of my time during the last six years in camp, where leisure hours are abundant and where literature is scarce, I read closely the Engineering News and a few other periodicals furnished by my newsdealer. But often in reviewing a back number I find articles which (due to some happening in my daily practice) awakens new interest; and such was my experience to-day in the letter "Literature for the Young Engineer," by Mr. Arch. R. Eldridge (Eng News, Feb. 20, 1902). Theory amuses and greatly excites the curiosity, but practice is inspiring.

The self-evident truths of mathematics are cold, inflexible facts, which must be blended with demonstrative results to make them appealing to the beginner. Chemistry cannot be taught from the text-book alone; neither can mechanics or engineering. Professional book writers cannot be practical field engineers; they point the way, but fail to warn us of the pitfalls; we learn of those dangers from the pilgrims who have passed over the road. I do not set up any claim to a successful passage myself, because I have entertained a false idea of the profession. For fear of showing my ignorance, I dared not go in a straightforward manner and ask information of others. But the one lesson I have learned is that all men who have gained prominence in any profession are delighted at an opportunity of revealing this thoroughness. The student has no other way of showing a deep interest.

In response to a dispatch not long since, I made a jump from a line of geodetic levels on the Connecticut River to a section of Texas which had enjoyed a sudden enhancement in real estate values from $5 to $5,000,000 per acre in three days. I found myself on the field in company with two local engineers armed with the abstract field notes, etc., but to my discomfiture and surprise the distances were all given in vara, the length of which I had not the remotest idea.

To conceal my ignorance, I found an excuse to take the abstract to my room and search for a clue, which I finally discovered in the shape of a number multiplied by 0.36 in pencil on the cover and the product expressed in vara. The reciprocal of 0.36 I found to be 2.78 ft., or 33⅓ ins., which is the length of a vara. I was afterwards complimented by one of these engineers upon my knowledge of Texas matters, and he recalled my familiarity with their standard measure as a notable feature, at which time I made a confession and a fast friend. The best advice I can give is, "Ask Questions."

W. P. Bullock, C. E.

Letot, Tex., May 20, 1902.

(Our correspondent also encloses a brief table, which will be worth copying in the note-book of any engineer who may have occasion to practice in the Southwest.—Ed.)

33⅓ ins., or 2.78 ft., = 1 vara.
5,000 vara square, or 4,425 acres, = 1 league.
1,000 vara square, or 177 acres, = 1 labor.
5,645.37 sq. varas, or 43,560 sq. ft., = 1 acre.
208.71 ft., or 75.13 vara square, = 1 acre.
To reduce varas to feet divide by 0.36.
To reduce square varas to acres, multiply by 0.000177.

Using the Run of the Crusher for Making Concrete.

Sir: In commenting editorially on Major Symons' article on the Buffalo Breakwater (Eng. News, May 29, 1902), there were some points mentioned which I would like to bring out more clearly. You expressed a fear that when the inspection was less rigid there might be a danger of

not getting the proper proportion of mortar and stone to make a good concrete by using the "quarry run" instead of a uniform size. This danger is not as great as would be supposed. In the case cited you will notice that there was the same amount of mortar material used as there was stone of all sizes. As a perfect concrete only requires enough mortar to fill the voids, and as the voids in broken stone of uniform size amounts to about 42%, it will be seen that there is ample excess of mortar in this case even if there were no sand in the broken stone. Some of the gravel mentioned, however, may have been large enough to act as stone, thus reducing somewhat the apparent excess of mortar. If the designing engineer knows that the inspection is going to be poor, he can so arrange his proportions of cement, sand and stone as to provide for an excess of mortar, and then there will be no damage done, as the voids will then be all filled, even with indifferent mixing and ramming. The writer performed some experiments not long ago which showed conclusively that concrete could be made of assorted sizes of stone which would be just as strong as that made from uniform sizes when considerably less mortar was used, thus securing the same strength for less money. The reason for this is that the per cent. of voids when there are various sizes of stone used is less than in the case where the sizes are all exactly the same. In the experiments just mentioned these voids were only just filled in both cases, and the difference in the amounts of mortar required to fill these voids was therefore saved without any loss of strength. This, however, is only a theoretical experiment, and might not be a very great gain in practice, as a considerable excess of mortar must be used in any case to insure good results. The greatest gain by using the "quarry run," however, was lost sight of entirely in your editorial comments; that is, the sand produced by crushing the rock, which is so carefully screened out by the majority of engineers, is at least 50% better than any natural sand that can be found anywhere. Even the dust in this sand (which, say will pass a 100-mesh sieve) is fully equal to any ordinary natural sand. All of this was carefully shown in my experiments published by the Franklin Institute in 1895.

In the face of all of these facts, it is difficult to see why so many engineers will insist in paying a much higher price for an inferior article. Your argument that a uniform relative amount of mortar making material cannot be maintained does not seem to me a valid one, for the reason that the engineer can easily specify the minimum amount of sand and cement that will be required to fill the voids when the least amount of sand is formed in the broken stone, or, if he wishes to take no chances at all when there is no sand in the stone, and if the stone at times has a greater amount of sand than usual, this would only give an excess of mortar, which is not objectionable, except that it increases the cost. This, however, would be more than offset by the saving due to accepting the rock just as it leaves the crusher.

A. S. Cooper, U. S. Asst. Engr.

Savannah, Ga., June 2, 1902.

Formulas for Computing the Cement Required for Concrete.

Sir: In Engineering News of Dec. 5, 1901, I offered what purported to be a rational formula for determining the amount of cement required for any given concrete, and I based the formula upon two theories, the first being that sand ordinarily contains a certain amount of dust as fine, or almost as fine, as the cement itself, and while water can fill the voids of such sand dust, cement cannot. Second, I assumed that while broken stone, when wet and rammed, shrinks in volume, it does not shrink, but actually swells when sand or mortar is added in quantity sufficient to fill voids determined by the water test.

Mr. Robert E. Horton, in your issue of May 29, takes issue with the assumptions that I made, and presents another formula, based upon no rational assumptions at all. Mr. Horton cites the experiments of Mr. George Rafter, with which I am quite familiar, as I was Assistant New York State Engineer at the time Mr. Rafter's later work was in progress. Mr. Horton says that instead of swelling broken stone upon adding mortar it actually causes shrinkage, unless the volume of mortar exceeds the voids in the stone. I need not enter into any argument to prove that this statement is erroneous, for a cursory reference to Baker's "Masonry" will satisfy any one of the facts; but I would call attention to the error which Mr. Horton falls into in assuming that because dry broken stone having 43% voids may have its voids reduced to 37% by wetting and ramming, it follows that mortar will have the same effect as water in assisting shrinkage.

Reasoning by analogy is especially dangerous in matters of this kind. Mortar has great viscosity, water has none to speak of; a perfect mixture of stone and mortar is never secured in practice so that in one part of a batch of concrete, mortar will be in excess and in another part the reverse. No amount of ramming can force an excess of mortar over to a place where there is a deficiency, if the spots are separated even by a few inches. This is one reason why concrete is porous.

There is still another reason, for unless mortar is so wet as to form a grout it holds the stone apart by virtue of its frictional or viscous resistance. If instead of reasoning by analogy from wet sand or wet stone, a few experiments with mortar itself be tried, no one will contend that concrete occupies less space than the loose stone of which it was made. The one example that Mr. Horton gives of concrete made by Mr. Rafter is, if I mistake not, not a quotation of actual facts, but a deduction from scattered data in Mr. Rafter's reports; for I can find no statement therein that 6.25 cu. ft. of loose stone actually made 5.8 cu. ft. of concrete as stated by Mr. Horton, and I assume that Mr. Horton arrived at this conclusion from another statement of Mr. Rafter's that wet stone was rammed so as to reduce the per cent. of voids from 43 to 37, which is quite another matter. If, however, Mr. Rafter did actually find such a srinkage in the concrete, it is the only instance of the kind that I have ever seen published.

In the very issue of Engineering News containing Mr. Horton's letter, Major Symons gives the quantities of material required to make a cubic yard of the Buffalo breakwater concrete, showing a decided swelling, even when the volume of gravel used is added to that of broken stone, from which it appears that in stating that a swelling takes place I am not in such great error as Mr. Horton asserts. Mr. Horton has evidently misapplied my formula, or there is a typographical error, for by no means can the formula be made to give a less volume of concrete than of broken stone as it would appear from the figure (5.54) given by him.

Finally, this is a matter of theory and of fact, and not one of ethics, wherefore I shall not discuss the proposition that it is "a very dangerous proposition to allow a contractor to assume that about 1-10 volume of the concrete is to be unfilled voids." Any contractor who knows the weight of a cubic foot of concrete as compared with a cubic foot of stone is quite well aware of the existence of voids whether he be "allowed to assume" it or not.

Yours truly, H. P. Gillette.

791 Powers Block, Rochester, N. Y., June 2, 1902.

The Parabola for Empirical Formulas.

Sir: In representing results of experiments or tests by means of empirical formulas, the parabola is usually employed. Other curves often satisfy given conditions, but only by intersecting rather than by approximately coinciding with the curve connecting the series of values obtained.

The general equation of the parabola, which allows four conditions to be imposed (instead of three by the common form), is, however, seldom used. This is due not only to the more complex form of the equation, but also, very likely, to the fact that while the problem is so apparently simple, yet errors in the computation of the constants cannot be discovered until the operation is almost complete. When an error is made, the whole previous work is usually found to have been wasted, and the computer must go back to the very beginning.

On this account it is desirable to find a method of checking the work at an intermediate point. In the following is given a method of determining the constants in the general form of the equation of the parabola which enables such a check computation to be made.

The general equation of the parabola is

$$(y + px)^2 + rx + sy + t = 0.$$

Suppose x to have the known values A, B, C and D, in succession when y has the corresponding values M, N, P and Q.

Let

$$M + Ap = X; \quad (1) \qquad P + Cp = Z; \quad (3)$$
$$N + Bp = Y; \quad (2) \qquad Q + Dp = U. \quad (4)$$

Then the four equations for the computation of the constants, p, r, s, and t, are

$$X^2 + rA + sM + t = 0. \quad (5)$$
$$Y^2 + rB + sN + t = 0. \quad (6)$$
$$Z^2 + rC + sP + t = 0. \quad (7)$$
$$U^2 + rD + sQ + t = 0. \quad (8)$$

Which equations may be solved by means of the following:

Let

$$e = B(P - Q) + C(Q - N) + D(N - P); \quad (9)$$
$$f = A(Q - P) + C(M - Q) + D(P - M); \quad (10)$$
$$g = A(N - Q) + B(Q - M) + D(M - N); \quad (11)$$
$$h = A(P - N) + B(M - P) + C(N - M); \quad (12)$$

and

$$a = A^2e + B^2f + C^2g + D^2h; \quad (13)$$
$$b = AMe + BNf + CPg + DQh; \quad (14)$$
$$c = M^2e + N^2f + P^2g + Q^2h; \quad (15)$$

then

$$p = \frac{-b \pm \sqrt{b^2 - ac}}{a}; \quad (16)$$

Since p is now known, then X^2, Y^2, Z^2 and U^2 can be computed. No formulas are necessary, therefore, for the computation of r, s, and t. Before doing this, however, it is important to know that no error has been made.

The following are test equations:

$$e + f + g + h = 0; \quad (17)$$
$$Ae + Bf + Cg + Dh = 0; \quad (18)$$
$$Me + Nf + Pg + Qh = 0; \quad (19)$$
$$X^2e + Y^2f + Z^2g + U^2h = 0; \quad (20)$$
$$b^2 - ac = efgh. \quad (21)$$

If these last five equations are satisfied, there certainly can be no error. It will be noticed that two values of p can be found One of them may have to be rejected.

It may require several computations to get a satisfactory approximation. The usual error is that the tangents at the ends are unsatisfactory. This may be rectified generally by taking three points and assuming a tangent at one of them.

This is done in the following manner:

Let x have the known values A, B, and C, and y have the corresponding values M, N, and P, and let z = A, and y = M, let

$$\frac{dy}{dx} = \text{tangent} = T.$$

Then the previous equations apply with the following exceptions, which are numbered the same as before, but with the addition of a subscript:

$$U^2 = 2(p + T)(Ap + M); \quad (4a)$$
$$U^2 + r + sT = 0; \quad (5a)$$
$$e = T(C - B) + N - P; \quad (9a)$$
$$f = T(A - C) + P - M; \quad (10a)$$
$$g = T(B - A) + M - N; \quad (11a)$$
$$a = A^2e + B^2f + C^2g + 2Ah; \quad (13a)$$
$$b = AMe + BNf + CPg + (AT + M)h; \quad (14a)$$
$$c = M^2e + N^2f + P^2g + 2MTh; \quad (15a)$$
$$e + f + g = 0; \quad (16a)$$
$$Ae + Bf + Cg + h = 0; \quad (17a)$$
$$Me + Nf + Pg + Th = 0; \quad (18a)$$
$$b^2 - ac = -h^2fg. \quad (19a)$$

It is impossible to give the proof of these formulas within any reasonable limitations of space. Equation (21) was discovered by the merest accident.

C. H. Lindenberger, Assoc. Am. Soc. C. E.

29 Adelaide St., Detroit, Mich., April 30, 1902.

Computing Dredged Material in Situ

Sir: In reply to the query of "R. S.," in Engineering News of April 17, as to the most correct method of computing dredged material in situ in a basin 1,000 ft. long by 375 ft. wide, with side and end slopes of 1 on 2, the material being of a rock nature, we beg to submit the following, which is employed by us:

At the beginning of the contract the bottom was comparatively level, irregularities in the rock being filled by silt. On the original survey soundings were taken, within the limits of the basin proper, at the intersections of perpendicular lines 50 ft. apart each way. This was considered near enough together to allow the assumption that the surface of each 50-ft. square was a plane. The average depth was computed from these soundings by the method given in Henck's "Civil Engineers' Pocket Book" for determining the amount of material removed from borrow-pits. This method is as follows (see Fig. 1):

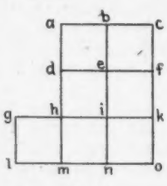


Fig. 1.

If a, b, c, etc. represent the soundings at the corners of 50-ft. squares, and x be the number of such squares, then let

S_1 = a + c + g + etc., or, in general, the sum of all soundings affecting only one square.

S_2 = b + d + f + etc., or the sum of all soundings affecting two squares.

S_3 = h, or sum of all soundings affecting three squares.

S_4 = e + l, or sum of all soundings affecting four squares.

Then the average depth $= \frac{1}{4x}(S_1 + 2S_2 + 3S_3 + 4S_4)$.

At the completion of the work, another survey will be made similar to the original, except that soundings will be taken 25 ft. apart each way, instead of 50 ft., as the bottom will probably be more abruptly irregular than before work was begun. From these soundings the average depth will be computed by the same method as above. The difference between these averages will give the average cut. This cut, multiplied by the total area, will give the volume of material removed.

Upon the original survey, soundings were also taken on the 50-ft. lines, 25 ft. beyond the limits of the basin proper. After the final soundings have been taken along

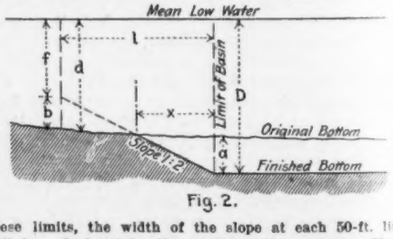


Fig. 2.

these limits, the width of the slope at each 50-ft. line will be calculated by the formula given on page 98 of Carhart's "Civil Engineers' Field Book," which, adapted to this case, is as follows (see Fig. 2):

$$x = l\frac{a}{a+b}$$

Where x = width of slope.
l = distance between inner and outer soundings, 25 ft. in this case.
a = cut, or difference between original and final soundings at limit of basin.

$$b = d - f = d - (D - \frac{1}{2}).$$

d = original depth, 1 ft. beyond limit of basin.

$$f = D - \frac{1}{2}.$$

D = final depth at limit of basin.

Having found x for each 50-ft. line, the quantity of material in each intervening section may be calculated by the prismoidal formula.

A combination of the above plans is slightly more laborious, but much more accurate than the rough method often employed, in which the sum of a number of soundings, taken at irregular distances, is divided by the total number to obtain an average. The only inaccuracy lies in the assumption that the surface of each section is a true plane. Where the bottom is more irregular, soundings should be taken nearer together, to keep down the error arising from this assumption.

Having examined all books at hand and found no literature on the subject, this scheme was devised by us. Being young engineers, we would appreciate any comments from those more experienced, especially as to a shorter yet accurate way of dealing with the slopes.

Respectfully, M. S. C.
——, April 29, 1902. J. S. C., Jr.

The Proposed New Safety Appliance Law.

Sir: I have read, with care, your reply to my communication in your issue of May 15, and while I will concede to you sincerity of purpose and spirit, when you say that "Engineering News would favor additional legislation for the reduction of accidents in the railway train service if convinced that such legislation would really accomplish the end sought," I would say that your attempt to prove that the proposed amendments will not reduce the record of accidents, betrays you into a medley of inconsistencies (not to say self-contradictions), and "consistency is a jewel."

In the last Interstate Commission's Annual Report, issued in January, 1902, the record of accidents to railway employees during the previous year was 42,193, including 2,550 killed. If the law is technically complied with in the general car equipment of to-day, it is worse than a failure so far as securing the conditions of safety are concerned, for it is evident—as thousands of railway trainmen testify—that the present equipment has not only augmented dangers that have always existed, but has served to introduce others which were hitherto unknown.

You contend that the coupling and uncoupling of the air-brake hose, as it is now done, is not particularly dangerous, and yet the very report, to which you call my attention, clearly announces the fact of great danger, which you will find on page 74. The paragraph in question, which deals with the air-brake hose, and the present method of coupling and uncoupling it, concludes with the announcement, "Injuries to trainmen from this cause have been somewhat common, and some of the injuries fatal."

Under the old link and pin regime a man could direct a link from the pocket of one drawhead into that of another as he stood erect or walked between the cars, but in the case of coupling and uncoupling the air-brake hose under the present system, the switchman has to crawl under the cars, and do the work with his hands—often (when everything is frozen up) having to lie prostrate on his back; in this position he is helpless, and a false or mistaken signal or a second's miscalculation on the part of the engineer involving the moving of the cars as much as three of four feet must result in his death or maiming.

To say that a device which makes it unnecessary to go between the cars, that is, a device which couples the air-brake pipes itself, "will show no real gain to the safety of trainmen in its use," makes me believe that the author of such a statement has not studied the conditions.

Such a device—an automatic air-brake coupler—is now in use on some of the fastest trains in the United States, as you can readily ascertain, if you wish, and I know that the officials of the roads running these trains would not be using the same if they did not know of their safety and certainty.

Recurring to the car coupler question, I concede that the type of coupler now in use has come to stay, and any improvements which are made must be within the lines of this type. I only ask for improvements on this type, nothing more. As to the test of this coupler made in 1885 upon a curve having a radius of 282 ft., I call your attention to the fact that at that time the longest cars in freight service were not more than 32 ft.—most of them less—and within such a circle a polygon having 40 sides, each side 32 ft. long, can be drawn. This goes to demonstrate that two cars 32 ft. long on a curve of this radius stand at an angle of only 9°. It is an easy matter to have the drawheads couple at an angle of 30° when made according to the several designs which you illustrated in your issue of Jan. 30th. You also call my attention, to prove the "soundness of your position," to the Accident Bulletin for July, August and September last. This record, in its last analysis, completely repudiates the assumption made by the "News." The number of accidents to employees for these three months was 8,976, including 615 killed. When we take into consideration the fact that the most favorable conditions prevail during these three months, both as to weather and the general slackness in train service, this is a most startling record. This number multiplied by four, places the year's record of accidents at 35,904, and it is only reasonable to apprehend that the final record will show a marked increase over this number. Of the number given in this quarterly report 504 were killed and injured in "coupling and uncoupling cars."

I ask the "News" in all candor, would this record have been made if there is not something inherently defective or radically wanting in the couplers in general use? If these devices should couple by impact, as trainmen desire, under all conditions where couplings have to be made, and if they could be "uncoupled from the side of the car" at all times, there should not be a single record of an accident from these causes.

In conclusion, I wish to remind the "News" that the American people are now holding an inquest over this terrible record of its slaughtered and maimed manhood, repeated year after year with an ever increasing ratio, and the verdict which will be rendered will be in accordance with the truth, the whole truth, and nothing but the truth.

If the amendments that are couched in Bill 10,934 become a law, the railroads will have ample time and opportunity to change their equipment to conform to its provision.

When this change is complete, what natural result will follow? Is it not evident that besides a great reduction of accidents to both patrons and employees—the first thing to be considered—a great reduction in cost of service will ensue; that instead of the record of broken lugs and guardarms, as was shown in the Engineering News of the 22d inst., the couplers will be relieved from the punishment which causes the same by the severe lateral strain that is now imposed upon it; that a corresponding reduction will be made upon the wear on the flanges of the wheels, the draft timbers or rigging, and in fact all parts of the car? Will not the record of derailments and trains parting be reduced in the same proportion? In fact, can the unbiased mind anticipate anything but that the most beneficent results will follow the change which these amendments forestall?

T. J. Hennessey,
Chairman of the Railway Commission of Missouri.
St. Louis, Mo., May 28, 1902.

Methods of Testing Fireproofed Wood.

Sir: In connection with the article which lately appeared in Engineering News and the work which the New York Building Department is now carrying on, a description of the methods lately employed by the writer in testing several samples of fireproof wood may not be out of place. An oak plank and a white pine plank were sawed up into pieces about 2 ins. × 4 ins. × 6 ft, and a special mark branded in the end of each. One piece of each kind was then laid aside for reference, and the different companies engaged in the fireproofing of wood were solicited to take and fireproof the other samples. Upon the return of all the samples, they were sawed into pieces of various sizes suitable for undergoing the following tests:

(a) Notes as to the discoloration suffered by the samples treated as compared with those not treated.
(b) The increase in weight caused by the treatment.
(c) The effect upon carpenter's tools.
(d) Comparative test as to which took varnish and polish most readily.
(e) The effect of moist air upon varnished and unvarnished surfaces of the wood.
(f) The effect of "weathering" by alternately soaking and drying.
(g) The so-called "splinter test," using pieces ¼ × ¼ × 3 ins.
(h) A special Bunsen burner test to determine fire-retarding qualities.
(i) Standard Navy tension test.
(k) Standard Navy bending test.

Tests (a), (c), (d) and (e) were by eye alone. In test (c), while the effect upon saws is considered by many carpenters as worse than upon other tools, the effect upon planes was selected as being most accurately observable. A plane was carefully sharpened before the test of each sample and its edge examined with a magnifying glass. The specimen was then planed down ¼-in. with the plane given but a small set. The edge was again examined with the glass and the amount of nicking noted. The amount of the chemical collected in the throat of the plane was also noted. In test (e) the samples were laid across a parallel-sided vessel containing a little water. After a week the amount of the chemical which had "crystallized" out and the general appearance of the sticks were noted. The sticks were also weighed before and after this test to see if any great amount of moisture had been absorbed or chemical lost. The effect upon nails, screws, etc., might have been tested in this connection, but would have taken longer time.

In test (f) the samples were alternately soaked for eight hours each day and dried for 16 hours. After 12 days of this treatment, pieces were cut from the center of each specimen and submitted to the Bunsen burner test described later. The samples were also weighed before and after treatment.

Test (g) was the standard splinter test of the navy with a cherry-red plate, except that the size of the pieces was somewhat larger than usual. The use of large "splinters" was to obtain results somewhat similar to those obtained in Professor Woolson's "timber test," but without the possibility of such scientific accuracy.

Test (h) was considered of most value and was most carefully carried out. Pieces ¼ × ¼ × 3 ins. were cut from the edge and center of each specimen. Exact equality of size was obtained by running all pieces through a buzz saw. A Bunsen burner was then arranged with an ordinary retort holder, so that when the specimens were laid across the center of the ring they were in the hottest part of the flame. The interval after being placed in position until flame appeared (if at all) was noted. The length of time it lasted was also noted. The experiment was continued until the specimens fell apart from their own weight by being completely burned in two, or for 10 mins. if they had not separated before that time. The time up to the point of separation was noted. If the piece did not break after 10 mins., it was carefully examined to see what portion of its cross-section had been turned to *ash*. The length of glow after removal was also noted in all cases when the pieces did not break. The kind and amount of fumes given off by the wood were also observed, but no care was taken to note the same.

Several points may be noted with regard to the last test. The burner was shielded by a cylinder of tin, but this did not form a draft chamber in any way, and would not have protected the flame completely from any large external draft. All pieces were most completely turned to ash at two points, one on each side of the center, where oxygen could most readily reach the wood. Some difference was found in different burners, and so a single one was used for all work at this time, and can be used for all future comparisons. A 2½-in. ring was used to support the specimens, which were placed so that their lower surface was just at the top of the central blue cone of flame. This test is subject to the objections urged by Professor Woolson against the burner used in the navy shaving test, but is believed to be one which can be readily standardized, and it can be used by any one at all conversant with a Bunsen burner. It is therefore rather more practical than his, and is believed to possess a relatively large degree of accuracy.

The following rules might be laid down: The burner to have a diameter of ⅜-in.; the supply of air to be such as to give a perfect flame; the gas pressure to be such as to give a central blue cone 1¾ ins. high; the specimen to be planed to ¼ × ¼ × 3 ins.; the specimen to be placed upon supports 2½ ins. apart; the specimen to be placed centrally over the flame; the specimen to be placed so that its lower edge is at the top of the central blue cone; the burner to be shielded by a tin cylinder 12 ins. in diameter and extending 6 ins. above the specimen; the time before the specimen flames to be noted (care should be taken not to confuse the flame of combustion with that of the chemical compound in the wood); the length of time the specimen flames to be noted; the length of time until the specimen is completely burned at its center as shown by its falling apart to be noted.

By faithfully observing these points it is believed that a high degree of uniformity can be obtained by different observers so that results differing in time and place can be properly compared.

The possibility of a still better test along the above lines may exist. Although no experiments have been made by the writer the thought suggested itself that it might have been better to use a thin slab of wood, about 4 ins. × 4 ins. × ⅛-in., supported at the ends, and to place a small weight about one-half inch in diameter in its centre with the flame directly beneath. This test would come nearer to actual conditions where fires have to attack the surface of a board than in any other way. The time which it takes to burn through so as to let the weight fall would be the direct means of comparison.

Yours truly, E. P. Goodrich.
Brooklyn, N. Y., May 23, 1902.

Stresses in Masonry and Concrete Arches.

Sir: In Mr. Buel's article on the Luxemburg Bridge (p. 362 of your issue of May 8) it is asserted that "to-day we solve these stresses (in an arch ring.—L. J. J.) with as great accuracy and certainty as we do those in a simple truss or girder."

In an editorial in the same number you say, commenting on another article: "About all that has been concluded in the matter up to the present is that some of the main factors entering into their (masonry arches.—L. J. J.) calculation cannot be defined precisely, and that any analysis is at best an approximation."

A third article, in the same issue, Mr. Luten's, on "Design of a Concrete-Steel Arch Bridge," begins with a reference to the design of an arch bridge being usually "dependent upon indeterminate external forces and upon doubtful assumptions as to internal stresses."

The last two of these three statements encourage me to believe that others besides myself would welcome an

article from Mr. Buel explaining the methods of analysis referred to in the first of these statements.

Very truly yours, L. J. Johnson,
Assistant Professor of Civil Engineering.
Harvard University, Cambridge, Mass.,
May 10, 1902.

Sir: In your issue of May 8, in the article by an American designer of masonry arch bridges, the author makes the statement that in France and Germany some concrete-steel bridges "of very long spans" have been built. To my knowledge the French and German engineers use for long spans the three-hinged concrete arch without steel reinforcement.

The author is mistaken on this point, but not more so than when he claims, in speaking of the calculations of the strains in long-span masonry or concrete arches, that: "we solve these stresses with as great accuracy and certainty as we do those in a simple truss or girder."

As to masonry arches, I can quote, and most engineers will agree with it, what the Engineering News in the same issue says editorially:

About all that has been concluded in the matter (i. e. in the calculations of the strains in masonry arches) up to the present is that some of the main factors entering into their calculations cannot be defined precisely, and that any analysis is at best an approximation.

On the subject of concrete arches there has been a great deal written of late and if there is any one point on which the authors of these papers have agreed, it is on the great importance and also on the great uncertainty of our knowledge of the modulus of elasticity of concrete—assuming even, that all concrete, composed of no matter what kind or size of stone or gravel, what kind of sand, what proportion of cement, sand and stone, whether mixed wet or dry, laid in the cold of winter or the heat of summer, etc., has one and the same modulus of elasticity. It has been stated, for instance, by Mr. R. S. Buck, in a discussion on steel-concrete construction at the annual convention of the American Society of Civil Engineers last summer, that the opinions of engineers as to the correct modulus of elasticity of concrete range from 700,000 to 3,000,000. What degree of "accuracy and certainty" can then be obtained in the calculations, on the elastic theory, of the strains in a concrete arch (not to speak of the assumptions which with our present limited knowledge have to be made when the concrete is reinforced by steel) will be apparent. Very truly yours, Carl Gayler.

St. Louis, Mo., May 17, 1902.

Sir: Mr. Buel's article on the Luxemburg Bridge in your issue of May 8, leads me to add to the discussion of some of the questions involved.

It hardly seems to me that the argument for a parabolic rib for the Luxemburg arch, instead of the three-centered curve adopted, can have any basis except personal taste, which is always a doubtful guide; Mr. Buel advances the argument that the parabolic rib would be better "because the proper curvature of such a rib is still an open question," which would also prove that any other form would be better, and is merely an expression of his personal preference. The parabola is the equilibrium curve for uniform horizontal loading, and hence is desirable in steel arches, where the columnar supports of the roadway are not an important part of the load; but in the Luxemburg arch, the stone columns constitute a much greater part of the loading than the light concrete-steel roadway; and the heavier loading near the abutments calls for sharper curvature at those points; the three-centered curve used is the curve of equilibrium for that structure, and if efficiency is to be desired, is to be preferred to any other. It is also aesthetically correct, if we admit that the "curve of duty is the line of beauty," which is quite generally accepted as the basis of aesthetic design.

Viewed from this standpoint, Mr. Wilson's criticism in your issue of March 27 is manifestly unjust: far from appearing as though the curved column were bending beneath the load, the column is curved to meet the load, and it is the flat parabolic rib instead that has the appearance of failure at that point, and that actually would fail if designed with a rib of the same thickness as the three-centered rib. The fact that an arch "looks right" to the layman, means usually that it follows the usual form in his locality. Striking examples of this fact are the bicycle which "looked right" eight years ago, but is now an "ice wagon" compared with more recent types, and the locomotives that "looked right" ten years ago. The more scientific methods usually in use abroad for the design of arches have taught the layman there that the multi-centered curved ribs present the better appearance, while the cruder method in vogue in this country, of using the segment of a circle and then supplying enough more material to make up for lack of brain work, has perhaps produced a more or less general opinion that an arch flat at the haunches looks right.

The use of a segment of a circle for the extrados and an ellipse for the intrados of an arch rib, as suggested by Mr. Buel, lacks flexibility and consequently adaptability; for both of these curves are determined independently of the depth of loading; thus, having the rise and span given, both the ellipse and circle are fixed; but the curve of equilibrium of an arch does depend upon the depth of loading. While the use of these curves for a filled arch, or for a masonry arch with heavy columns, will in general produce better results than the circular segment, still they are at best but a rough approximation, and their efficiency in any particular case purely a matter of chance.

The mathematical problem suggested, of determining the curve bisecting the rib between the circle and the ellipse, although of little practical value, is not difficult of solution, provided the bisection be made on the normal to the circle.

Assuming,

a = radius of circle,
b = horizontal semi-axis of ellipse,
c = vertical semi-axis of ellipse,
d = distance of center of circle below center of ellipse,
e = thickness of crown:

the equations of the circle and the ellipse referred to the center of the circle as origin of co-ordinates, are:

$$x^2 + y^2 = a^2 = (c + d + e)^2$$

and

$$\frac{x^2}{b^2} + \frac{(y - d)^2}{c^2} = 1.$$

Transforming into polar co-ordinates, these equations become:

$$r = c + d + e$$

and

$$\frac{r_1^2 \cos^2\theta}{b^2} + \frac{r_1^2 \sin^2\theta - 2\,d\,r_1 \sin\theta + d^2}{c^2} = 1.$$

Solving the latter equation for r_1, we get

$$r_1 = \frac{b^2 d \sin\theta + \sqrt{b^2 c^2 [(c^2 - d^2)\cos^2\theta + b^2 \sin^2\theta]}}{c^2 \cos^2\theta + b^2 \sin^2\theta}.$$

The radius vector of the curve bisecting the distance between the two curves will be one-half the sum of the radii vectores of the two curves, or

$$r_2 = \frac{r + r_1}{2}.$$

Combining this with the expressions for r and r_1, and transforming back to rectangular co-ordinates, we get,

$$2(x^2 + y^2) - (c + d + e)\sqrt{x^2 + y^2} = \frac{b^2 d\,y + \sqrt{b^2 c^2 [(c^2 - d^2)\,x^2 + b^2\,y^2]}}{c^2\,x^2 + b^2\,y^2}.$$

Whatever the usefulness of this equation may be mathematically, it has little practical value, because the easiest way to construct the curve is to draw the circle and the ellipse, and bisect the distance between. Moreover, as pointed out above, this curve can approximate the equilibrium curve only by chance since it is entirely independent of the depth of loading. A more rational method of design, would be to determine the curve of equilibrium for the given loading, and then lay it out by means of a multicentered curve approximating it closely. No engineer of practical experience in the erection of arches will attempt to lay out the centers on a strictly mathematical conic-section curve; even the ellipse and the parabola are more accurately determined, on a large scale, as multi-centered curves than by means of co-ordinates, and the use of co-ordinates is rough and inaccurate in comparison with arcs of circles for laying out and erecting masonry arches.

I would add that one of the most interesting points in connection with the Holy Trinity Bridge was omitted in Mr. Buel's description: the arches are not semi-ellipses, but have a point at the crown, being approximately two-quarter ellipses overlapping at the crown, for each arch. This point is, perhaps unfortunately, hidden by an ornamental key. Very truly yours,

The National Bridge Co., Daniel B. Luten.
Indianapolis, Ind., May 28, 1902.

(Proofs of the three letters above were submitted to Mr. Buel, and we append his reply as follows:—Ed.)

Sir: The apparent discrepancy between a statement in my article on the Luxemburg Bridge, in your issue of May 8, and statements in an editorial, and in Mr. Luten's article in the same issue, which Mr. Johnson calls attention to, is as important as anything connected with masonry arches, and should be cleared up, if possible.

The statement that, "We solve the stresses in an arch ring with as great accuracy and certainty as we do in a single truss or girder," is a comparison. How accurately do we solve them, in practical work, in a simple truss or girder? Not so very accurately or certainly, for the following reasons:

(1) The "common theory of flexure" is not exact.

(2) Few engineers proportion a girder by the moment of inertia, but generally by dividing the bending moment by an arbitrary depth, either neglecting the web or making an arbitrary allowance for it.

(3) As to the shearing stresses in the web of a plate girder, a considerable difference of opinion was developed by a discussion in the Engineering News in 1898 or 1899.

(4) The secondary stresses in a riveted girder or truss (very considerable) are rarely, if ever, solved in practical work,

(5) Most important of all, the amount of stress due to impact is indeterminable. It may be anything up to 100% of the live load in some cases such as steel bridges. The live load on a 75-ft. deck plate girder railway bridge, for example, is about 75% of the total load. The judgment or opinion of bridge engineers on the proper percentage to "allow" for impact, whether by percentage or by unit stress formulæ, varies greatly. Thus it will be seen that a very large element of doubt exists in all cases as to the actual amount of the working stress.

Taking a 75-ft. railway arch, designed by the unit stress, the live load was only 16% of the total load, or only about one-fifth as large a proportion as for the deck plate girder. Then if the element of doubt on account of the stress due to impact is 25% for the deck plate girder, it would be only 5% for the masonry arch, or in that proportion for any amount of indeterminate impact.

As to the amount and direction of the external forces acting on an arch ring, three methods are available to determine them with practical exactness.

(1) To construct the arch with hollow spandrels, bringing the loads on to the ring vertically, at fixed points, as exemplified in the Jaremcze Bridge, the Luxemburg Bridge, Mr. Thatcher's design for a 300-ft. masonry arch proposed for Schenley Park, Pittsburg, and Prof. Ware's Memorial Bridge designs. If the spandrels are filled solid with earth or other material, the amount and direction of the pressure on the ring may be determined by

(2) The statical method published by Prof. W. H. Burr in the "School of Mines Quarterly" for November, 1898, or

(3) The method of least work.

Very important long span arches in the future will probably be built with open spandrels, giving only vertical loads. For short spans, the horizontal or conjugate pressures of the solid spandrel filling can be neglected without seriously affecting the economy of the design. Neglecting the conjugate pressures is always on the side of increased safety.

The loads being determined or assumed, as they are generally assumed in steel bridge designing, the stresses throughout the ring can readily be determined with exactness by the elastic method, which can be found in "Stresses in Bridge and Roof Trusses, Arched Ribs and Suspension Bridges," by Prof. W. H. Burr, published in 1882, revised in 1893, and also in Prof. Cain's contributions to the "Van Nostrand Science Series," Nos. 42 and 48. This method may also be used to determine the effect due to small horizontal movements of the abutments, just as it is used to determine the thermal stresses, the two being identical in effect and in solution.

In addition to the above, I am informed that a recent German publication contains the complete application of the method of least work to the solution of stresses in arches. This is open to those who do not credit the elastic method, and gives the maximum of refinement in stress calculations.

Your correspondent from St. Louis says that "to his knowledge the French and German engineers use for very long spans the three-hinged concrete arch without steel reinforcement." I think it is very generally known that they do. The Engineering News has shown and described several such, but that is no evidence that they do not also use concrete-steel arches of long spans. Your correspondent says I am "mistaken on this point," but here are some examples: 1 span of 137.76 ft. at Steyr, Melan concrete-steel, three-hinged; 1 span of 132 ft. at Bremen; 1 span of 128 ft. at Wildegg; 2 spans of 128 ft. each at Aran, and 1 span of 98.5 ft. over the River Saale. The last four arches are of Monier concrete-steel, without hinges.

Excepting the bridge at Steyr, these were all built between 1890 and 1893, and were taken from a list of about one hundred concrete-steel bridges in Europe, which was prepared about 1894.

I have no accurate data of bridges built since that time, but am credibly informed that several hundred concrete-steel spans have been built in Europe during the past six or eight years.

Your correspondent says I am also "mistaken" on the point that "we solve these stresses with as great accuracy, etc. . . ." Again he bases this assertion on negative evidence, and has proved nothing. He says "most engineers will agree with it." Perhaps they will, but if they do it does not prove anything, because few engineers in America have had very extensive experience in arch calculations and design, and very few indeed have calculated many arches by modern methods, because until recently it has been quite unusual for an American engineer to meet with more than one or two masonry arch problems with considerable spans in the entire course of his career, if indeed he met with any. During the past six years the writer has designed a considerable number of masonry arches, and assisted in the design of others. These have covered all sorts of conditions and spans up to 283 ft. A number of them have been built, and have all been successful. They were all calculated by the elastic method.

It is evident that the elastic method is not understood when your correspondent argues that the exact value of the modulus of elasticity ("E") is required to obtain ex-

act results. Excepting for thermal stresses it is not at all necessary to know the value of E. True, it is assumed that E is constant throughout the ring, but if not constant then the values may be ascertained. The variations referred to are the extreme range for all kinds of concretes and various conditions, both here and in Europe.

That E will be practically constant throughout a given concrete ring, where the materials and conditions are practically constant will be generally admitted by those who have given most study to the question and analyzed the cause of variation. Also that for any given case E can be predetermined by experiment for the materials and conditions required. As noted above, this is only required for the determination of the thermal stresses, which are not very important with a material in which the E is as low as in concrete. Engineers with the largest experience in masonry arch work usually neglect it altogether.

Of course, in a concrete-steel combination, it is necessary to know the ratio of the E for the concrete and the E for steel, but after one has calculated a few spans, using this combination, he will see that by assuming a ratio on the side of safety, very little will be lost. The range of values for the E of the concrete is by no means as large as indicated after inapplicable data have been sifted out. Moreover, as stated above, it can be very closely determined for any particular case, where the magnitude of the work or possible savings that might be made, warrant it.

It is perfectly evident that your correspondent from Indianapolis has not carefully read the article he attempts to criticise or else his references are not fair. I made *no* "argument for a parabolic ring" whatever. The suggestion of a parabolic ring by the Engineering News was certainly a good one, because it opened a question that may be profitably discussed. It is probable that the Luxemburg ring closely fits the line of pressure, but it is just as probable that a ring with an elliptical intrados and segmental extrados would fit it just as closely. This statement is based on the results of stress sheets of a large number of arches, calculated by the elastic method. If as good results can be attained with an elliptical intrados as with a three-centered or multicentered one, then the ellipse should be given the preference because it is the "fairer" curve. "Personal taste" or sentiment cannot be entirely separated from the designing of structure without some detriment. This form of ring is not at all inflexible, for while the span and the rise fix the intrados they do *not* fix the extrados nor the neutral axis.

If your correspondent had comprehended the "mathematical problem suggested" (by me) he would have perceived that what was desired was a working method for drawing the neutral axis directly without laying down the ring and bisecting. In other words, to draw directly the line arch. Moreover the bisection should be made on the normal to the neutral axis. The formula given has no practical value.

Over two years ago I got an equation by combining the transferred equations of the ellipse and of the circle, but it was of no practical use. It is doubtful if one can be written simple enough for ordinary use.

Your correspondent seems to have confused the question of the shape of the ring at the point of change of radius with the change in the style of masonry introduced at that point in the Luxemburg Bridge, which was clearly brought out by the Engineering News editorial.

That all arch rings should be designed so that the line of pressure for maximum loading will nearly correspond with the neutral axis, will hardly be questioned. The line of pressure should be located by an exact method, for one or more cases, and the ring then be adjusted to it, unless (as in some cases with the writer's work) it needs no adjustment.

There is, I believe, a true value in the opinion of the "layman." Certainly arch bridges are built principally for his use and enjoyment, and he generally pays for them. But the true verdict as to the artistic merits or demerits of any work should be sought neither from the professional nor the layman, but from posterity of the third or fourth generation, or later. For this reason the Florentine Bridge, that has been much admired for hundreds of years, was used as an illustration.

In an article by the writer, in the "Engineering Magazine" for April, 1899, mentioning the Holy Trinity Bridge, will be found the following: "The very slight point at the crown is concealed by decoration, giving the arches the appearance of being elliptical." That the builder considered this line a defect, is proven by the fact that he attempted to conceal it. In the article under discussion, they were described *not* as "semi-ellipses," as your correspondent reads, but as fairly representing semi-elliptical arches.

Your correspondent says, "No engineer of practical experience in the erection of arches will attempt to lay out centers, etc." Now, I have had a little experience of this kind, having both designed and laid out a large number of centers for spans up to 125 ft. It is just as simple a matter to lay out an elliptical center as a circular one, and more simple than a multicentered one. The way to do it is not by co-ordinates, but by fixing a wire of a length exactly equal to the major axis, at the two foci and scribing the curve. This was done in several cases in Porto Rico, for spans up to 55 ft., without difficulty, notwithstanding the fact that the available labor and facilities were very inferior. Very respectfully yours,

Albert W. Buel.

32 Broadway, New York city, June 10, 1902.

Notes and Queries.

In the article on the Fond du Lac sewage disposal works, in our issue of May 22, the table of gagings of sewage flow was improperly credited to Madison, instead of Fond du Lac. The gagings were made at intervals of 8 or 10 minutes, and not hourly, as might be inferred from the heading.

Mr. E. M. Douglas, of the U. S. Geological Survey, writes:

I wish to call attention to a typographical error in your issue of May 1, p. 353, which Mr. Wm. Harkness repeats in the issue of May 29, in his communication regarding the accuracy of spirit leveling as carried on by the U. S. Geological Survey.

The allowable error in the leveling work of that survey in feet is 0.05 $\sqrt{\text{distance in miles}}$, not .5 $\sqrt{\text{distance in miles}}$, as quoted by Mr. Harkness. This limit was fixed by the officers of the Geological Survey after careful consideration of the needs of the work and of the standards set by other organizations.

The limit of error quoted by Mr. Harkness for the New York state levels is practically that adopted by the Mississippi River Commission, and is slightly less than the limits fixed by the U. S. Coast and Geodetic Survey and the Missouri River Commission.

Mr. Cyrus C. Babb, of the U. S. Geological Survey, the writer of the letter of May 1, also asks us to correct the error noted by Mr. Douglas.

BOOK REVIEWS.

DIRECTORY OF DIRECTORS IN THE CITY OF NEW YORK.—The Audit Co., of New York, 43 Cedar St. Cloth, 5½ × 7⅞ ins.; pp. 994. $3.00.

The fourth edition of this useful compilation is much enlarged by an appendix, which follows the list of officers and directors in important railway and industrial corporations with the names of the subsidiary companies controlled by these corporations. The list of directors is arranged in alphabetical order; the name followed by that of all corporations, etc., with which the individual is connected. In some cases this list of interests is a formidable one; as in the case of Senator Depew, who is an officer in 67 corporations.

NATIONAL IRON AND STEEL, COAL AND COKE, BLUE BOOK.—An authentic and concise list of firms, corporations, and individuals, engaged in the production of iron and steel, coal and coke, in the United States; the plants or mines operated, their location, description, equipment, etc. Edited by B. H. Morwood. R. L. Polk & Co., Publishers, 2 and 4 Smithfield St., Pittsburg, Pa. Cloth, 6 × 8 ins.; pp. 669. $7.50.

This volume is issued to meet a demand for concise information on the subject handled, and expressed in the title. The publishers state that the material is carefully gathered from original sources. The arrangement is alphabetical, irrespective of location; though in the case of consolidations, the various organizations and individuals entering into the consolidation are given under the main head. The statistics of plant and capacity are noted with each of these. Under coal, the various coal measures are handled separately and alphabetically; with the names of mines and operators and their addresses noted. It should prove a handy reference book for those interested.

DIE ASSANIERUNG VON WIEN.—Fortschritte der Ingenieurwissenschaften, Gruppe II., Heft 9. Edited by Dr. Th. Weyl. Paper, 7¼ × 11 ins.; pp. 194; 76 illustrations; 14 plates; 22 tables. Leipzig: Wilhelm Engelmann. $5.20.

This book, on the sanitation of the city of Vienna, is a companion to the preceding number of this series, which dealt with the sanitation of Paris. The present volume, however, treats its subject more fully than did the other. It is divided into two sections. The first of these presents a technical description of methods and constructions relating to the different departments of sanitary work in the city of Vienna. It takes up in succession the water supply of the city, its drainage, street cleaning and refuse disposal, the regulation of the Vienna River (a small mountain stream flowing through the city, whose greatly varying flow produced highly unsanitary conditions), the regulation of the Danube Canal, and the extension of the city and its control. All the illustrations are contained in this portion of the book. The second part, covering the last 65 pages, gives a brief historical review of matters of public hygiene in Vienna, and then deals at some length with the health statistics of the city.

WIRELESS TELEGRAPHY.—A Popular Explanation. By G. W. de Tunzelmann, B. Sc. Cloth, 5 × 7¼ ins.; pp. 104; 30 illustrations. London: The Office of "Knowledge," 326 High Holborn. 75 cts.

The matter of this book, the preface states, was in part originally published as a series of articles in "Knowledge," but includes also considerable additions necessary on account of the rapid development of the subject. The first chapter describes the earth-current method and the electro-magnetic induction method of communicating without wires; the remainder of the book deals with the third method, that of signaling by Hertzian waves. The author first attempts to make clear in popular language the nature of the ether as it is assumed to exist, and of disturbances in this ether, using mechanical models to supply analogues wherever possible. This leads to the discussion of the generation of electrical oscillations, the production thereby of waves in the ether, and the detection of these waves by resonators. Then the methods of Popoff and Marconi are described, and the results obtained by the latter are detailed. A farther chapter is given to syntonic systems. The entire treatment is free from mathematics, and is written clearly and in logical order. The widespread interest aroused just at present by wireless telegraphy and the remarkable results that have been obtained with it should commend this little volume to all (and especially to engineers) who have not followed the developments in this field or who wish to learn more about them.

LOCOMOTIVE SPARKS.—By W. F. M. Goss, Dean of the Schools of Engineering and Director of the Engineering Laboratory at Purdue University. New York: John Wiley & Sons. Cloth; 8vo.; pp. 165; illustrated. $2.

This little treatise deals in general with fuel losses from the locomotive. After discussing the general design and proportions of locomotives, with questions of draft, etc., the author describes the formation of "sparks" or cinders. Numerous road and laboratory experiments have been made to determine what loss of fuel is represented by these cinders, and the results are set forth at some length. The important question of spark prevention is then discussed, and various front-end arrangements are shown, with deflectors, screens, draft pipes, spark arresters and other devices, applied to both long and short smoke-boxes. One chapter is also devoted to the important matter of the action of the exhaust jet upon the fire, and its relation to the form of the smokestack. The chances of fire from sparks are also considered, and an appendix describes the locomotive testing plant of Purdue University. The book is rather unnecessarily padded in its mechanical make-up, but its author has done his work well and the book will take its place among the up-to-date treatises on railway mechanical engineering.

ARCHITECTURAL ENGINEERING.—With special reference to High Building Construction, including many examples of prominent office buildings. By J. K. Freitag, Assoc. M. Am. Soc. C. E. Second edition; rewritten. Cloth, 6 × 9 ins.; pp. 407; 196 illustrations. New York: John Wiley & Sons. $3.50.

This work treats of the steel framework of buildings, and takes up in connection therewith all matters bearing on its design. Fireproofing, floor and partition construction, and other subjects which relate to the work of both the engineer and the architect, are fully considered. Of the portions of the treatment that belong more properly to engineering, the chapters on columns, on windbracing, and on foundations are particularly exhaustive. A noteworthy feature of the book is the constant reference not only to variations in practice, but also to the requirements imposed by natural conditions, and by local regulations.

Since the first edition of this work appeared the art of city building construction has seen great development. Many large cities now have their tall office buildings, and practice in the general and detailed design of such structures has become more settled. The present edition is therefore a broader and more comprehensive treatise than was the original issue. In particular, it is more than ordinarily valuable, because it draws for its material upon most of the high buildings in existence, and illustrates all details of the subject matter with drawings and views from such existing structures.

CIVIL ENGINEERING AS APPLIED IN CONSTRUCTION.—By Leveson Francis Vernon-Harcourt, M. A., M. Inst. C. E. Longmans' Civil Engineering Series. Longmans, Green & Co., London and New York. Cloth, 5⅝ × 8⅝ ins.; pp. 624; illustrated. $5.00.

Science is so intimately bound up with civil engineering and the range of subjects coming within its scope is so wide, that it is an exceedingly difficult task to include in one book all that relates to the modern practice of constructive civil engineering. To specialize under each of the many branches of the subject would result in a series of volumes or a library of technical literature. Mr. Vernon-Harcourt, therefore, has wisely divided his topic under the five main heads of: Materials, Foundations and Roads; Railways, Bridges and Tunnels; Rivers, Canals, and Irrigation; Dock and Maritime Engineering, and Sanitary Engineering. Under each of these main heads he proceeds to outline present accepted practice, to illustrate with examples of actual construction various methods of performing work, and to give illustrations drawn to scale showing the plans followed out in individual enterprises. In each important case footnotes refer to the publication containing fuller details for the convenience of those specially interested. Following this general plan the author has produced an exceedingly interesting, as well as very useful compendium of civil engineering practice in construction; brought up to date and omitting practice no longer accepted, except where the latter is useful historically. The arrangement of subheads is unusually well selected, and comprehensive, and the language of the text is concise and clear; and the same remark applies to the excellent index. There is an entire absence of mathematics, as expressed by formula, the author leaving this branch of the subject entirely to specialized discussion in text-books, etc., existing elsewhere; but dimensions and cost of work are given wherever these are im-

The ... of the section in charge of each of our patrolmen ... with the character of the country and the difficulty ... traveling it, but in general one man has about 20 m... in charge and patrols it twice a week. After having ... ade a tour of inspection the patrolman mails a report ... d to the Seattle office, certifying the condition of the ...

Built as our line is, and inspected as rigidly as it is, we have ... inated entirely all troubles due to falling trees, running ... es or wind storms. In fact, our troubles narrow down ... entirely to those due to interference evidenced either ... malicious persons or boys shooting off insulators or throwing wires over the transmission lines. The only remedy ... this is to make an example of a guilty party, and the ... xperience of other transmission concerns has shown ... that such an example puts a quietus on the interference. We have had a law enacted in the legislature of this state making any such interference a penitentiary offense, but thus far we have been unable to convict anyone.

As soon as a short circuit occurs, the lines are tested out immediately, to find out on what section the trouble lies. The trouble is invariably on one circuit only, so that the entire load is immediately placed upon the other circuit pending the correction of the trouble. As soon as the trouble is located on a division, the patrolmen from each end of that division start towards each other in great haste to reach it and repair it.

Our apparatus is protected by lightning arresters installed on the main circuits at the primary station and each of the sub-stations. We have very little lightning in this country and only once, I believe, in three years, have these arresters actually been called to duty, and on this occasion they worked to perfection. All our circuits are fused at the different stations for 100% overload, so that in case of a dangerous short circuit coming in, the fuses open up and the apparatus is cut out.

As an improvement upon our own practice, and to make the protection of any long-distance system further assured, I would suggest that the triangle of wires be constructed so that the apex insulator will be below instead of above, for the reason that a wire—or anything thrown over the lines—will be less likely, under such an arrangement, to cross two wires. In our system the apex is above I would further suggest that the spacing in the triangle be greater for the same purpose, even though the inductive drop is thereby increased somewhat. Spacing should be at least 36 ins.

The insulator is the strong or weak point in a transmission system, and I am glad to say that we have been very successful, using the porcelain Imperial insulators, of the best quality. I would suggest, however, that the insulators receive a brown glaze instead of the white (as in our case) as they will thus present a poorer target for anyone aiming at them. We have had a great many insulators broken to the extent of the petticoats being shattered off, but the wire almost invariably remains upon the core of the insulator. This would not be true in the case of a glass insulator, which would be shattered to pieces, allowing the wire to come down upon the cross arm.

I would suggest, further, that the telephone system be maintained upon a separate set of poles, as trouble on the transmission line is very sure to put the telephone out of service if both are on the same poles. These suggestions we would certainly inaugurate in any new lines that we are to build. As it is, any interruptions we have, and they have now been reduced to a minimum, seldom last over three to six minutes, which is just long enough to test out the line and switch the load on to the circuit which is intact. The location of and repair of the break, of course, takes longer, depending upon the distance the patrolmen have to go to reach it, but the repair of this, as stated above, does not interfere with the service.

By L. Denis.*

The Quebec Jacques-Cartier Electric Co. has thus far had little experience with lightning trouble. Our transmission line consists of two three-phase 23,000-volt lines, some 18 miles in length, and in several places passing in the neighborhood of tall trees. It is protected at both ends, at the very points where the wires enter buildings, with sets of Wurts lightning arresters arranged in the standard Westinghouse fashion. These arresters are our only protection against lightning. Although they have been noticed to spark occasionally, we have never experienced more than the result of a partial short circuit from the discharge. We seem to have had more trouble from gradual discharges, and from induced charges that take effect on the low-tension side of our station transformers. On one occasion, one of these charges caused quite an amount of damage on the 2,000-volt switchboard, arcing to the ground from terminals leading to current transformers. In this case, as in others of the same nature, but less serious, apparently no damage was done to our station transformers. This locality has quite a reputation for the severity of its lightning storms.

By P. N. Nunn.†

We have, at our several stations in Colorado, Utah and Montana, a number of lightning-arrester installations. These installations are all of the Wurts type of non-arcing arrester, and consist of a number of paths to ground, with a number of choke-coils between the line and apparatus to be protected. The exact arrangements employed are various and for voltages ranging from 4,000 to 60,000 volts, the higher voltage being, in general, from star-connected transformers with neutral point grounded.

In all of these various installations an attempt has been made to improve upon the previous practice, and, in general, this has been successful. We have never had a serious disaster caused by lightning, or by the violent oscillations caused by the opening and closing of long power lines of large capacity and at a very high potential.

We have, however, had numerous small annoyances caused by lightning and the oscillations above referred to, and for this reason do not regard our present lightning protection as entirely satisfactory. We are now experimenting with the more recent type of arrester installation, including shunted and series resistances and fewer paths to ground.

By Henry J. Gille.*

The St. Croix Power Co. is operating a 25,000-volt transmission line approximately 30 miles long, from Apple River Falls, Wis., to St. Paul, Minn. The transmission line consists of two three-wire circuits on one line of poles. The poles are spaced at a maximum distance of 110 ft. The size of wire is No. 2, B. & S. medium drawn copper, one circuit being supported on each side of the poles on two cross arms in the form of an equilateral triangle with 24-in. sides. One of these circuits runs straight through without transposition, while the other is spiraled twice at equal intervals.

At each end of the line is located a lightning-arrester house. The house at the St. Paul end is within two miles of the sub-station and is also used as a cable-terminal house. At each end of the line is a choke coil on each wire and 12 2,000-volt lightning arresters. Each arrester has four air gaps of about ⅛-in. each; cylinders being 1 × 1¼ ins. in series with two graphite resistances, each having a cold resistance approximately of 450 ohms.

From the cable-terminal house the current is carried underground through cables at the line voltage to the sub-station. The cables are two in number; one insulated with rubber and the other with prepared paper, both being lead covered, and each of sufficient capacity to carry the entire load. In both cables there are three conductors, each conductor consisting of seven strands of copper wire. At the sub-station in St. Paul there are cable terminals, switching devices and static arresters. The static arresters are lightning arresters, the same as described above, and are connected the same as lightning arresters except that the center of the Y is not grounded.

During electrical storms the line is almost always affected in some way, sometimes very slightly and sometimes shutting the system down entirely. When the storm is severe we usually observe a discharge on one leg of the arresters. The discharge affects the generators at the power house practically the same as does a heavy short circuit and there seems to be a strong tendency for part of the generators to motorize, and always slow down. In some cases they have come practically to a standstill. We have had several cases where the lightning has apparently disregarded the choke coils and the lightning arresters, and damaged the static transformers.

At the sub-station the synchronous converters slow down, but apparently remain in step until the fields become practically dead. This occurs in about 10 seconds. When the generators begin to pick up again at the power house the rotaries also come up with considerable flashing at the brushes. Sometimes they come up with the polarity on part of the rotaries reversed. If they all come up right side up they pick up the load and carry it along as if nothing had happened, but if part of them come up wrong side up it is necessary to shut down and change the polarity.

The alternating-current system is not so easily affected as is the direct-current system. When the transmission line is affected by lightning discharge and the current comes back in the sub-station, the circuit breakers on the alternating-current feeders usually open up, especially on feeders where there are induction motors. This is without doubt due to the fact that the induction motors will take considerably more current to bring them to speed again than is required when they are up to speed; that being practically the only time when all the induction motors on the circuit are started at the same time, these circuit breakers therefore open up, due to a heavy overload.

The effect on the line is entirely dependent upon the severity of the electrical storm. If the electrical disturbance of the atmosphere is light, the lights in the city merely wink. Under these conditions the apparatus does not seem to be affected, but when the electrical disturbances in the atmosphere are very severe it is very difficult to keep the rotary converters in service, due to the fact, as explained above, that when they slow down some of them come up reversed, thus shutting down the whole system; or if they come up right side up, they have to pick up the load at zero, which puts a very heavy overload on them for a short time. This is liable to blow the alternating-current fuses and motorize the rotaries.

There is evidence on a great many poles on the transmission line of discharges jumping from the wire to the poles. We have not had poles so badly damaged that they have had to be replaced, but some of them were badly split. At the time of these discharges the insulators on the line were apparently not affected; as a matter of fact, we have had no insulators broken through lightning discharge.

The lightning arresters and static arresters are so adjusted that they discharge constantly, the discharge being very light, being visible only on two or three air gaps next to the line wire. The lightning arresters at one end of the line were very badly damaged during one storm last summer, when the discharge apparently jumped from the line to the ground, arcing across the cylinders without regard to the resistances, forming a straight path to the ground. How long this arc was held we do not know; however, it held long enough to do considerable damage to the cylinders and porcelain.

The trouble where no synchronous apparatus is used is not regarded as so serious, but all the companies that I have been referred to by manufacturers, who are operating synchronous apparatus, state that they have considerable trouble during electrical storms.

By P. M. Lincoln.*

The effects of lightning on the Niagara Falls & Buffalo transmission line may, for the purposes of discussion, be divided into two classes: 1, Those lightning discharges which cause destruction of apparatus attached to the transmission line; and 2, those discharges which cause a general short circuit, but without the destruction of any apparatus.

So far as destruction of apparatus is concerned, the Niagara & Buffalo line has been peculiarly fortunate. During the 5½ years of its operation, practically the only apparatus that has ever been destroyed by lightning has been lightning arresters. The exception of any importance to this statement was the short-circuiting of a 500-K.-W. transformer on one occasion at Tonawanda (about half way between Niagara Falls and Buffalo). The only other exceptions consist of one ammeter transformer and a few ground detectors.

In the matter of lightning arresters, however, the line has not been so fortunate. Several different styles and makes have been installed and tried with the result of ultimate disaster to the arrester. Failure has been due to the inability of the arrester to interrupt properly the dynamo current that follows the discharge, and the resulting short circuit at the arrester would usually put it out of business, at least temporarily, and occasionally, permanently. The conditions at Niagara are, of course, unusually severe. The low frequency and the large amount of power involved make it difficult to interrupt a short circuit when once started. Devices that work perfectly on higher frequencies and with less power back of them, have failed utterly on the Niagara & Buffalo line. One of the things which I consider that the experiences of this line have proven is that it is absolutely necessary to limit, by means of resistance, the dynamo current which flows on the discharge of the arrester. No matter what the number of gaps through which the discharge takes place, an arc once started seems to be maintained unless the dynamo current is thus limited.

The device that comes nearest answering our lightning-arrester problem is the one now in operation; that is, the so-called "low-equivalent" lightning arrester of the Westinghouse Electric & Mfg. Co. In that device the gaps have an ohmic resistance in series with them and another larger resistance in shunt to a portion of the gaps. This arrangement gives the line-discharging effect of the small series resistance and the current-interrupting effect of the combined series and shunt resistances. In their original form these were put into operation in the summer of 1899, and are still in use in a somewhat modified form. Our former experience, however, has led to the adoption of fuses in the discharge circuit, so that in the case of a short circuit taking place in the arresters, both line and arresters are protected; the line from a continuation of the short circuit, and the arresters from the damage that would necessarily follow that continuation. In all our lightning arresters, choke coils are put in the line and the discharge circuits tapped on the line side of the choke coils.

In the invitation to present these notes, the question is asked, "How frequently are your lines affected by lightning that your devices have failed to arrest?" Those occasions when the arrester conducts off the flash, but becomes short-circuited, can hardly be called failures to arrest. It is possible—and perhaps even probable—that other apparatus might have been destroyed had not the flash been taken care of by the arrester. In most of the failures to arrest, as observed on the Niagara & Buffalo line, the lightning has caused short circuits somewhere along the overhead line, sometimes with a simultaneous discharge across the gaps of the arrester and sometimes with no sign of such discharge. Our observations would indicate that the voltage necessary to jump over a wet

*Quebec, Canada.
†Provo, Utah.

*St. Paul, Minn.

*Niagara Falls, N. Y.

portant. This work embodies the experience of 36 years of active practice on the part of an eminent civil engineer, and to this personal experience is added that of others as gleaned from their writings and the reports contained in the technical journals. The nature of the work forbids more detailed description of its subject-matter; but it can be confidently stated that Mr. Vernon-Harcourt has well performed a most difficult task; and has intelligently and usefully condensed a vast mass of engineering knowledge and experience within this one volume.

PLATE LAYERS (TRACKMEN'S) GUIDE. With Tables and Diagrams of Switches and Crossings.—Compiled and published by Thomas Summerson & Sons., Darlington, England. Fourth Edition. Cloth, 8vo.; pp. 106. $2.

Although this book has been compiled by a firm manufacturing switches and frogs, it is not a catalogue or "trade publication," but a technical book on maintenance-of-way work, with special reference to switch work. It is prepared, however, for English conditions, with double-headed rails carried in cast-iron chairs, but the authors prefer the American practice of setting the rails vertical and using only a slight coning of the wheel to the English practice of coning the wheel 1 in 20 and tilting the rails correspondingly. The objection given to this latter practice is loss of adhesion and increased wear and tear due to slip, although it is claimed to save wear on the wheel flanges. The guard rail flangeway is usually 1¾ ins. for wheel flanges 1¼ ins. thick, the wheels having the flanges 4 ft. 5½ ins. apart. For sharp turnout curves it is recommended that the frogs should be built to fit the curve. About 12 pages are devoted to the requirements of the Board of Trade in regard to railway construction and operation. Diagrams and tables are given for the laying out of single and double-track turnouts, three-throw switches, single and double crossovers, slip switches, etc. These are given for nine different gages, from 1 ft. 6 ins. to 5 ft. 6 ins., for the reason that English engineers are employed on railways of all these gages at home, in the colonies and in foreign countries.

THE BRITISH RAILWAY POSITION.—By George Paish. With an introduction by George S. Gibb, General Manager of the Northeastern Ry. London: The Statist. Cloth; 8vo.; pp. 322. 10 shillings, $4.

This book is composed of a reprint of articles written for "The Statist" by Mr. Paish, after a visit to the United States, his aim being to show that by following certain features of American railway practice the railways of Great Britain may be operated with much greater economy and efficiency than at present. That this is to a large extent the case is shown by the action of some of the leading British railways within the past few years, as in increasing the train loads, introducing better systems of compiling their operating statistics, etc. It does not, of course, follow that every good point in the operation of railways and railway affairs in this country would be equally advantageous or even desirable in the smaller country, with its different conditions, but there is no doubt that British railways have reached a position where it becomes absolutely necessary to effect in some way greater economy in their operation.

Not the least interesting feature of the book is the introduction by Mr. Gibb, who visited this country last year with other officers of his company. He discusses at some length the question of statistics, showing the greater superiority of the American ton-mile unit to the British train-mile unit, and he concludes that British railway managers have been severely handicapped by the lack of proper and reliable statistics. On the subject of train loads and car loads, he also believes that much can be done in England by increasing these loads, but he points out the great differences in traffic conditions and shows that it is unsafe to make comparison on a mere basis of average loads. Many other points must be taken into consideration, and it appears that much more information is needed before safe conclusions can be drawn as to what British railways can do in the matter of increased train loads and decreased train mileage.

In a comparison of the results of British and American railway working, Mr. Paish shows that the average train load of the Pennsylvania R. R. is 484.6 tons, while than of the London & Northwestern Ry. is 68.6 tons; on the former, the cost of hauling one ton one mile decreased 33⅓% between 1800 and 1900, while on the latter road it increased 24% in the same time; in the same period, the cost of carrying a passenger one mile decreased 13% on the one road and increased 11½% on the other. The book is full of comparisons of this kind, with tabular statistics of traffic and financial affairs. One curious statement is to the effect that British railways do not separate their passenger and freight expenses, and this alone would indicate the need for a better system of records and accounts. The articles as published originally, called forth considerable criticism, as might have been expected, and these (with the authors' replies) are included in the book. The shareholders in British railways are becoming alarmed at the decline in dividends, but nobody either in or out of the railway service seems to have a very clear idea of what to do or how to do it in order to start railway finances on a rise instead of a decline. It is feared that the competition of electric traction will seriously affect the earnings of steam railways, but Mr. Paish is of opinion rather that electric railways will benefit both the steam railways and the community at large. The last half of the book is devoted to chapters on the individual leading British railways, their traffic and finance, etc., and it closes with a chapter on Indian railways.

The book is well prepared and well written, and while it is not probable that it will lead directly to any of the improvements suggested, it undoubtedly marks an important period in British railway affairs, and indicates that present conditions cannot continue, but that changes must of necessity be introduced.

NOTES FROM THE ENGINEERING SCHOOLS.

THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY.—The summer course of 1902 is open in June and July, not only for students in supplementing the regular school year, but to all persons not students, but possessing the necessary qualifications. Particulars can be obtained of the Secretary, Mr. H. W. Tyler.

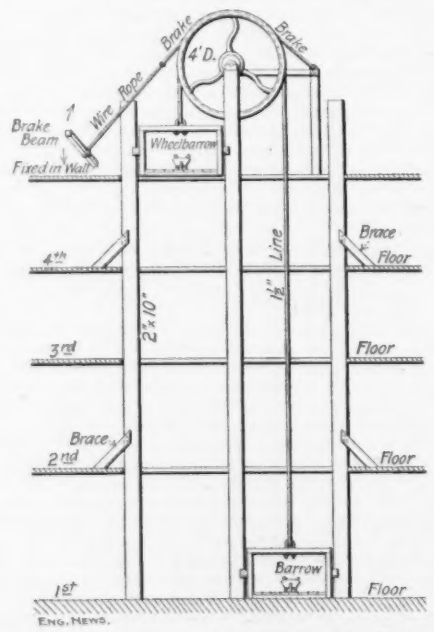
DARTMOUTH COLLEGE.—The faculty announce the founding of the Amos Tuck School of Administration and Finance, under the terms of the Amos Tuck Endowment Fund of $300,000. To this sum Mr. Tuck has added $100,000 for the erection and maintenance of a building for this school. The courses of the Tuck School are intended to prepare men for the more modern forms of business; or private banking, brokerage and investments, insurance, railway service and water transportation, foreign trade, etc.

UNIVERSITY OF MICHIGAN.—To the University Law School a practical course in conveyancing has been added, with a special professor. The course includes full and systematic instruction in the substantive law of conveyancing and a thorough drill in the actual preparation of all the more important forms of conveyancing.

A SIMPLE CONTRACTOR'S ELEVATOR FOR USE IN TAKING DOWN A BUILDING.

By Alfred H. Hartman.*

The work of track elevation through Wilmington, Del., now being carried out by the Philadelphia, Wilmington & Baltimore R. R. Co., has made necessary the tearing down of a great many buildings along the proposed new location through the city. The buildings have been sold separately



A Simple Elevator for Lowering Building Material.

for a small sum to local contractors who can use to advantage the old materials contained in the buildings.

In one of the large buildings now being removed the contractor, a young man of considerable ingenuity, has fitted up a novel elevator by means of which bricks and other material are carried rapidly to the ground floor without being damaged by falling.

As shown in the accompanying sketch, the elevator consists of two platforms made of rough lumber, suspended from a grooved iron wheel 4 ft. in diameter and 1½ ins. width of face. The guides consist of pieces of 2 × 10-in. stuff braced to the joists at each floor. The platforms are of sufficient size to hold one wheelbarrow. The bricks as they are torn from the wall are loaded into barrows, and these are wheeled directly onto the platform, which is adjusted to the level of the highest floor when the other platform just reaches the ground floor.

The excess weight of the loaded platform causes its rapid descent, raising the other platform with the empty barrow to the top of the building for reloading. A man with a lever and wire rope, attached to a simple friction brake of sheet-iron controls the movement of the wheel.

(The device described above is certainly an excellent illustration of the value of brains and ingenuity in the contracting business. It may be worth while pointing out that while the scheme could hardly be improved upon for the place where it was installed, it would be an easy matter to adopt it also to the hoisting of materials in building construction, or in the erection of high walls, dams, or other structures. To do this it would only be necessary to attach a simple water tank with each elevator car, with a pipe connection to the top, so that the tank on the upper car would be quickly filled and a drain into which the water in the lower tank could be discharged at the same time. Such a system has been used in the operation of cable incline railways, and it could be readily adapted to use on such a gravity elevator system as that herewith illustrated.

It may be well to point out that workmen should be strictly forbidden to ride on such elevators unless they are constructed with much greater care and provision for safety than is usually the case.—Ed. Eng. News.)

*Assistant Engineer's Office, P., W. & B. R. R., Wilmington, Del.

PROTECTION OF LONG DISTANCE TRANSMISSION LINES.*

By Charles H. Baker.†

The chief weakness in a transmission project is the transmission line itself. Although every precaution has been taken, and no expense spared in constructing well this artery between the generating point and the consumer, yet nearly all our troubles have centered here.

We do not think a transmission system can be entirely reliable without a double circuit. Our present system transmits from the generating point at 30,000 volts by two circuits, each to Seattle, and two circuits each to Tacoma. These circuits parallel each other for 20 miles, and at the 20-mile point they are interchangeable through a high-tension plug-board system. For this distance we therefore have more assurance of continuity of service than from this point to the terminals where only two circuits cover.

It is our purpose later on, and we think it a good plan, to put in a plug board at one or two other intermediate points, in order to be able further to divide or interchange the circuits. If there is a break on any circuit, it can, by means of these plug boards be located on a parallel short division and the circuit in trouble can be cut out and repaired.

It has been our practice to repair a circuit in trouble while current was running on the other circuit on the same sets of poles. An operation of this sort, however, must be undertaken by only skilful and cool-headed men. Our wires are spaced 30 ins. apart in the triangle.

About every fifth pole has a spare cross arm tacked upon it, and every half mile there is a spare pole resting on skids. The location of these spare cross arms and poles is known by the number of the pole at which they are located, and the patrolmen have a record of these, so that if there is any trouble he knows at once where to go for relief material.

Every three miles on our transmission we have a telephone booth located, which is commodious enough to contain also a few insulators, pins, wire, etc. The patrolman in making his rounds enters the booth and reports by telephone his presence there to the head works office at Snoqualmie Falls, and he also registers his call in the booth, so that his visits may be tallied at any time by the general superintendent or inspector. He reports the line "O. K." when he gets to the booth, if such be the case.

*Abstract of a joint paper by Charles H. Baker, L. Denis, P. N. Nunn, Henry J. Gille and P. M. Lincoln, presented at the annual convention of the National Electric Light Association at Cincinnati, in May.

†Snoqualmie Falls Power Co., Seattle, Wash.

Cochituate aqueduct from 0.7 to 1.3 ft. per sec., with a mean of about 1.0 ft. The errors in the computations of velocities, as far as they are affected by the meter ratings, are probably less than 0.3% in the former case and not more than 1.5% or 2.0% in the latter. It would seem that in the case of the Cochituate aqueduct a considerable gain in accuracy of measurement might be accomplished by the use of an especially delicate meter, designed for velocities under 1.5 ft. per sec. and kept for that use alone, as the wear incident to constant use under higher velocities, while having little effect on the rating above 2 ft. per sec., is felt very quickly on the lower end of the rating curve.

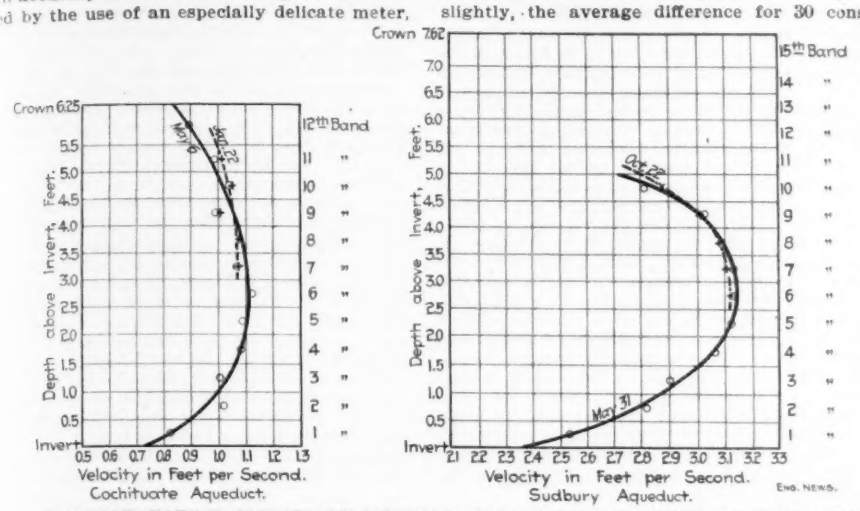


FIG. 4. REPRESENTATIVE CURVES OF MEAN VELOCITIES IN THE BANDS OF THE SUDBURY AND COCHITUATE AQUEDUCTS; ALSO CURVES FOR FINDING MEAN VELOCITY IN UPPER PARTIAL BAND.

The following method has been adopted in using the meter to obtain the mean velocity of flow in the aqueduct. The cross-section of the aqueduct at the gaging station is assumed to be divided into a series of 6-in. bands, as shown in Fig. 3. The meter is attached to a 1¼-in. brass rod sliding through a sleeve, pivoted at A. The rod is also provided with a handle shown at C, and a brass roller at B which travels in the grooves of the gaging board. This board is so designed that when an index on the rod at B (not shown on the diagram), is at any one of the graduations marked on the under side of each groove the meter is at the center of the correspondingly numbered square on the aqueduct section, and as the roller passes from end to end of the curved groove the meter traverses horizontally the bands in the aqueduct. It is now apparent that if the meter is started in square No. 1, and is then moved at an uniform speed through the successively numbered squares to the end of the upper submerged band, that the resulting record of the meter wheel is a mechanical integration of the velocities throughout the water section. In practice the horizontal speed of the meter has been fixed at 0.1 ft. per sec., hence in its operation the index must pass one graduation on the gaging board every fifth second. The operator takes his time from a metronome set to beat seconds, and he is checked on every fifth graduation by an assistant reading from a stop-watch. The total number of revolutions of the meter wheel divided by the number of seconds required for the observation represents the mean velocity of flow in the aqueduct.

If the water surface in the aqueduct is more than 0.5 ft. above or below the top of a band, the mean velocity for the upper partial band is obtained, as shown by Fig. 4. In such a case the mean velocity in each of the upper five fully submerged bands is integrated separately and plotted on cross-section paper. Through the points thus found a curve is drawn and extended to the elevation of the water surface; the mean velocity for the partial band being then read from the upper end of this curve. The velocity for the upper partial band often differs 6% from the mean velocity for the entire section, and as its area may be 10% of the total water area, it would plainly be including an unnecessary source of error if the velocity for the partial band were assumed the same as the mean for the balance of the section.

In making an observation with the meter the integration is always performed twice, once from surface to bottom, and again in inverse order, the average of the two velocities thus found being used for the computation of quantity flowing. The results of the two integrations usually differ slightly, the average difference for 30 consecutive sets of observations on the Sudbury aqueduct being 0.37%, and ranging from 0.00 to 1.18%; while for 30 sets of observations on the Cochituate aqueduct the average difference between the two readings of each set was 0.89%, and the range of differences from 0.00 to 2.5%. A comparison of these figures gives additional evidence that the meter is not well adapted to the slow velocities found in the Cochituate aqueduct. The velocity used in computing is always the mean of the two integrations, and while the average difference between these integrations may be 0.37%, as in the Sudbury aqueduct observations, yet it is believed that the average error of their mean is within 0.25%. Three sets of integrations made in the Sudbury aqueduct in immediate succession and under favorable circumstances, gave percentage differences in each set of 0.23%, 0.29% and 0.62%, respectively, but the three means were exactly the same. Two other sets, taken one week later, gave differences of 0.06% and 0.52%, while the means of each set differed by but 0.03%.

The two sources of error just discussed, namely, the change in rating, and the error of manipulation, when combined are probably seldom in excess of 0.6% in the case of the meter as used in the Sudbury aqueduct, and were it not for the uncertainty in regard to the value of the coefficient of cleanliness, which also includes any irregularities in the value of C in the aqueduct formula, our final computations should be within this limit of error.

The coefficient of cleanliness is the factor by which results computed from the aqueduct formula must be multiplied in order to agree with the quantity flowing as obtained from the current meter experiments. It varies with the changes in the character and amount of the deposits or organic growths on the interior submerged surfaces, and is always a direct measure of the carrying capacity of the aqueduct, as compared with its theoretical value. Fig. 1 shows the variations in this coefficient for both the Sudbury and the Cochituate aqueducts during a period covering 13 consecutive months, and presents several features of marked interest. The Cochituate aqueduct was cleaned during the period from May 7 to June 12, when it was not in use, and the resulting improvement in the coefficient of cleanliness was 7.2%, or from 0.998 to 1.070. The Sudbury aqueduct cannot be out of commission more than a day at a time, and hence is cleaned by instalments. The first few miles, including the portion adjacent to the gaging station, were cleaned on April 11, with a resulting gain in the coefficient of 11.6%. On April 18 a second section was cleaned, and an additional gain of 2.3% made in the carrying capacity of the aqueduct.

It will be noticed from the diagram that for the first few months after cleaning the deterioration is very rapid, and that subsequently the curve is quite irregular, at times showing an increase, and again a decrease in the value of the coefficient of cleanliness. One peculiarity which has been observed repeatedly in the coefficient curves is well shown on the diagram for the Sudbury aqueduct, in June, 1901. In this case the aqueduct had been cleaned within a few weeks, and the value of the coefficient had been decreasing quite rapidly since the cleaning. Early in June a sudden gain of 1.3% was made when the depth of water in the aqueduct was increased about 2 ft. in six days. This was followed by a downward slope of the curve, nearly parallel to the decline shown just previous to the rise, the depth of flow in the aqueduct also being reduced during this period. With a second marked increase of depth another sudden upward jump occurs in the coefficient curve.

The explanation of this phenomenon is believed to be substantially as follows: As soon as the aqueduct is refilled after cleaning, microorganic growths attach themselves to the submerged surface and commence to flourish. They multiply very rapidly at first, and then more slowly as the available space is filled and they become crowded. If the depth of flow is much increased the effect of the addition of the cleaner surface to the submerged area of sides and bottom is shown by a sudden rise in the value of the coefficient of cleanliness; but this gain in the coefficient is only temporary, and is quickly lost as the newly submerged surface becomes fouled. If, now, the depth of flow is decreased for a considerable period and the organisms which thrive only under water be left exposed

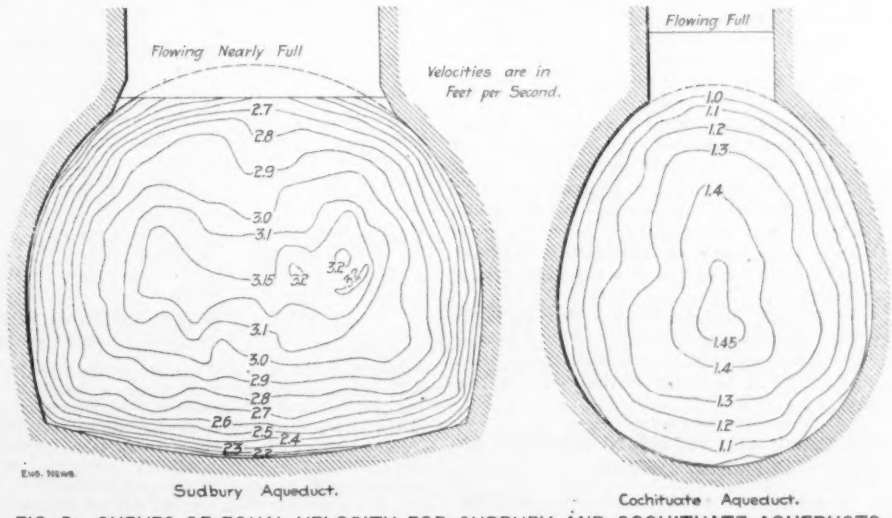


FIG. 5. CURVES OF EQUAL VELOCITY FOR SUDBURY AND COCHITUATE AQUEDUCTS.

insulator does not differ greatly from that required to jump across the gaps of the lightning arrester. In case such a short circuit is once established anywhere along the line, it almost always continues until the current is pulled off the lines, in spite of the fact that the distance between our conductors is 36 ins. Most of our lightning interruptions are of this nature. No permanent damage is done. All that is necessary is to take off the current for an instant; supply of power can be resumed immediately.

An examination of the records for the past three summers—those of 1899, 1900 and 1901—shows that during that time 18 interruptions occurred due to lightning, five of which occurred within a space of about three hours, during a storm of unprecedented severity. The average duration of the interruptions has been about four minutes. Considering the prevalence of lighting on the Niagara frontier, I consider this record a very good one.

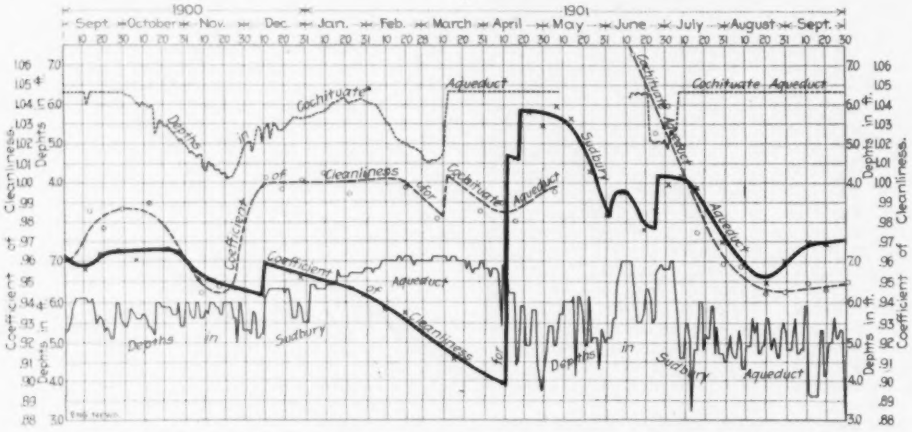


FIG. 1. DIAGRAM SHOWING DEPTHS OF FLOW AND COEFFICIENT OF CLEANLINESS IN THE SUDBURY AND COCHITUATE AQUEDUCTS.

MEASUREMENT OF THE FLOW OF WATER IN THE SUDBURY AND COCHITUATE AQUEDUCTS.

By Walter W. Patch.*

The method generally followed in computing the flow of water in aqueducts is either by the use of some formula, such as the well-known Chezy formula ($V = C\sqrt{RI}$), or by measurements on a weir, or with a current meter. The ideal condition exists when there is enough difference in elevation between the source of supply and the receiving reservoir to permit the installation of a standard weir, with a self-registering apparatus for taking a continuous record of the depths on the weir crest. Such a device is entirely free from that element of uncertainty which is always present when computing the flow from any formula, due to the daily changes in the condition of the interior surface of the aqueduct, and which can be taken account of in the formula only by changing the coefficient C. A good current meter, carefully rated and properly used, will give results comparable in point of accuracy with those obtained by the use of a weir, but this method is an expensive one, and of necessity is intermittent in its operation.

The inaccuracy of the formula method, when used without any additional check, has been thoroughly demonstrated by an extensive series of observations made on the flow through the Sudbury and Cochituate aqueducts of the Metropolitan Water-Works, of Boston. These aqueducts, through which passes the daily water supply of Boston and its Metropolitan district, are so built that it is not practicable to locate weirs in either of them, hence the daily flow must be measured by some other means, and the method which has finally been adopted is a combination of current meter and flow formula.

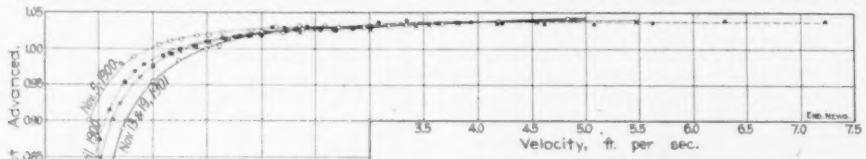


FIG. 2. RATING CURVES OF SUDBURY CURRENT METER; 10-VANE WHEEL.

When the Sudbury aqueduct was under construction a temporary weir was placed in it, and the depths of water flowing past a given station in the aqueduct were noted for various quantities passing the weir, from 13 to 72 million gallons per day. From this data a table was computed giving the values of the coefficient C in the formula $V = C\sqrt{RI}$ (in which V is velocity in ft. per sec., R is area divided by wetted perimeter, and I is sine of angle of slope of aqueduct), and this table was extended to cover the entire range of velocities in the aqueduct up to that for full depth, or for a maximum quantity of about 109 million gallons per day when the interior surface of the brickwork in the aqueduct is moderately clean. A recording apparatus actuated by clockwork placed in the head house of the aqueduct gives a continuous record of the depths of water flowing; and the quantities corresponding to any depth of flow are taken from a table computed from formula $V = C\sqrt{RI}$, the values of C being those obtained as just described, and I being constant.

In the Cochituate aqueduct, either end, or the whole aqueduct may be submerged, so that I as well as C is a variable, and no table of flows can be computed which is based on the depth of water in the aqueduct. Values of C, however, have been tabulated, and from simultaneous observations on the elevation of the water surface, taken three times each day at stations about eight miles apart, values of I are found, and the quantity flowing in the aqueduct is computed in the same way as for the Sudbury aqueduct.

The values of C as tabulated for each aqueduct vary according to the depth of flow from 120.5 to 122.5 in the Cochituate aqueduct, and from 96.3 to 140.8 in the Sudbury aqueduct, and are only correct for a moderately clean surface on the interior of the brickwork of the aqueduct. The particular condition of cleanliness for which values of C are tabulated only obtains for a short time each year, and at other times may range, as shown in the diagram, Fig. 1, from 89.7% to 103.6% of the tabular values in the Sudbury aqueduct, and from 94.4% to 107.0% in the Cochituate aqueduct. It will at once be evident from an inspection of this diagram, that unless the degree of cleanliness of the interior of the aqueduct is known, that the computed flows may be in error. This coefficient of cleanliness is determined weekly in each aqueduct by means of the current meter.

The current meter consists of a ten-vane wheel, 1 in. in length axially and 3⅝ ins. in diameter, attached rigidly to a brass supporting rod and fitted with an electrical counter. It is rated every six months over a measured course in quiet water; the rating track being on a wharf about 150 ft. long, located where the water is over 10 ft. deep. The meter to be rated is attached to a carriage running on iron rails. Between the rails the track is graduated at 1 ft. intervals by conspicuous marks, and by timing the passage of these marks to the beat of a metronome fastened to the carriage it is possible to attain great regularity of speed at rates from about ⅓ ft. to 7 ft. per sec. The counter is automatically thrown into and out of gear at points exactly 100 ft. apart and the time is taken by an assistant with a stop watch. As there is generally some subsurface current, even in apparently calm water, the track is traversed twice in each direction for every point plotted on the rating curve.

Fig. 2 shows the rating curves of the Sudbury current meter for the past two years, the ordinates of the diagram being revolutions of the meter wheel per foot advanced, and the abscissas

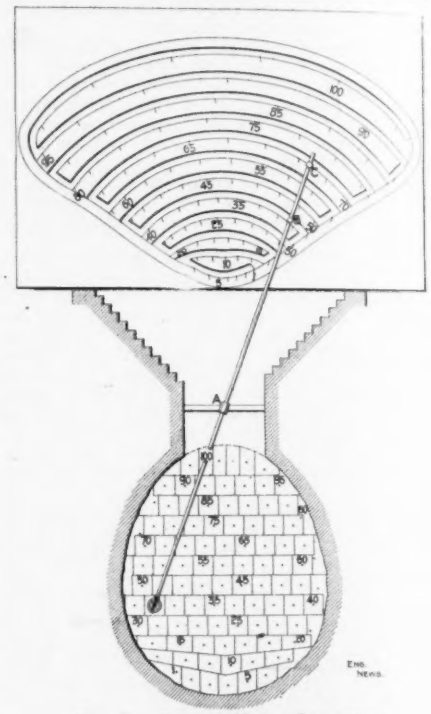


Fig. 3. Current Meter Apparatus.

velocities in feet per second. The revolutions per foot advanced are converted into revolutions per second; and are then tabulated, to the third decimal place, for each 0.01 ft. of velocity; so that mean velocities may be read by interpolation to the nearest 0.001 ft. per sec. It will be seen from the diagram that for velocities above 2 ft. per sec. the successive ratings are generally less than 0.5% apart, while for 1.0 ft. per sec. they may differ by 2.5%, and for slower velocities the divergence rapidly increases. For a frictionless wheel the rating curve would be a horizontal line, hence the dropping of the curve as the velocities diminish is a measure of the friction in the meter bearings. Between the ratings of April and November, 1900, the Sudbury meter was repaired and adjusted, and the resulting improvement in the bearings is shown very plainly in the November rating. The two ratings since November, 1900, each show an added increase in friction, probably due to wear in the bearings of the wheel, as this meter is in frequent use in both the Sudbury and Cochituate aqueducts. The ordinary range in velocities in different portions of the cross-section of the Sudbury aqueduct is from 2.3 to 3.3 ft. per sec., the mean being about 3.0 ft.; and in the

*Assistant Engineer, Sudbury Department, Metropolitan Water-Works, South Framingham, Mass.

to the air, they soon perish, and leave the surface upon which they were attached as if it had been partially cleaned, so that when it is resubmerged an improvement in the coefficient of cleanliness may be expected. Other more gradual gains in the value of the coefficient, such as those shown in the case of the Cochituate coefficient during September, 1900, and in the Sudbury aqueduct coefficient from the middle of August to the middle of September, 1901, and which cannot be explained by the theory just advanced, are believed to be caused by an actual decrease in the quantity of organic growths, or to changes in species. Such conditions might be brought about by a lack of proper food supply, by the incursions of other predatory forms, or by changes in temperature.

The sides of the aqueduct, as they appear immediately after being drained for cleaning, are covered by a dark brown slimy deposit, usually about 1-16-in. in thickness. This deposit in its natural submerged condition may occupy four or five times as much space as it does when drained, but even on this supposition would only cut out 1% of the cross-sectional area when the water is flowing 7 ft. deep. The deposit seldom contains much fresh water sponge or other large aquatic growths, and, of course, the filamentary algae are not present, as they do not grow in the absence of light. The principal attached forms seem to be colonies of polyzoa, which intercept large quantities of amorphous matter and numerous diatoms and other microscopic organisms, which are entrained by the current. It is difficult to conceive how the removal of such a coating, covering but 1% of the cross-section of the aqueduct, can effect an increase of 14% in its carrying capacity. Yet that this is undoubtedly true is shown by Fig. 1. It is evident that the coating acts as a brake to reduce the velocity of flow, rather than as an obstruction cutting off area of cross section.

Fig. 5 shows the distribution of velocities in the cross-sections of both the Sudbury and the Cochituate aqueducts, as determined by experiment. The Sudbury aqueduct diagram represents about the average condition, while the velocities shown for the Cochituate aqueduct are somewhat larger than those usually found.

In measuring the flow in the aqueduct by the method just described, the best results are obtained by very frequent determinations of the points whose locus is the coefficient of cleanliness curve; the degree of precision possible of attainment being limited by the amount of error in the values assigned to each individual point. In the case of the Sudbury aqueduct, where current meter observations are taken weekly, and the velocities are favorable for meter measurements, it is thought that the final computations are within 1% of the true quantities. The size of the probable error might be somewhat reduced by more frequent meter observations, but it is doubtful if the gain in accuracy would compensate for the increased expense. The present annual cost of this method of gaging the flow is about $350 in excess of the assumed expense attending the measurement of the same quantities by means of a weir. If this is capitalized at 4% it gives $9,000 as the permissible outlay which might have been made in order to place a permanent weir in the aqueduct.

Mr. Frederic P. Stearns, M. Am. Soc. C. E., is Chief Engineer of the Metropolitan Water and Sewerage Board, and Mr. Desmond FitzGerald, M. Am. Soc. C. E., is Engineer of the Sudbury Department.

EXPRESS TRAINS AT FOUR-MINUTE INTERVALS ON AN ENGLISH RAILWAY.

The celebration over the coronation of King Edward will include a great naval parade, or review, and there will be a large fleet of excursion steamers to carry sightseers from the docks at Southampton to the review. In connection with the steamer service, 50 express trains, at four-minute intervals, are to be run by the London & Southwestern Ry. between London and Southampton, 79 miles. At the time of the Jubilee naval review, in 1897, this road ran 37 special trains (with 350 passengers each) between these points at the rate of 12 trains per hour, or at five-minute intervals. For the present review there will be 46 to 50 special trains, accommodating about 400 passengers each, and these will be dispatched at the rate of 15 per hour, or at four-minute intervals. The following extract from an English paper will give some idea of the magnitude of the problem which confronts the operating officials in providing for such an extraordinary extra traffic in addition to the regular traffic:

In round numbers, 20,000 persons, distributed through about 50 special trains, will have to be landed at the docks before midday. Then, at night, when the illuminations are over, the whole gigantic operation will have to be reversed, with this difference and added perplexity to the company's officials—namely, that owing to the irregular arrivals of the steamers, a working time-table will have to be improvised virtually on the spur of the moment. The most elaborate preparations are being made at the Waterloo (London) terminals, and all down the line, for coping with this huge volume of traffic. It is intended to limit the weight of the trains to 260 tons behind the tender; that is, to 10 coaches.

Of course, in working heavy trains of this character, with such a short interval between, nothing sensational in the way of speed can be attempted. The company will be quite satisfied, and passengers also should have nothing to grumble about, if the journey of 79 miles can be performed, as it will be scheduled, in 110 minutes, without an intermediate halt. But to accomplish the task every train must keep exact time, and everybody concerned must be tuned up to concert pitch. A lazy signalman could work dreadful mischief, and a locomotive breakdown is too dreadful to contemplate. Nevertheless, the traffic, which will be much relieved thereby. But the opening of these additional tracks carries with it conversion of existing ones, for the "down fast" has to changed into the "up fast," and the "up fast" into "up slow." Then, again, all the signaling arrangements have to be completely remodeled, and the tracks nected on with another by means of new cross-overs. get this much-needed relief ready in time hundreds men are toiling day and night.

Nothing is to be left to chance where the review is concerned. On Sundays dress rehearsals are regularly taking place. Special trains, made up exactly as will be on the great day, and conveying the head officials —superintendent of the line, locomotive superintendent, chief engineers of widening works, signaling superintendents—together with a picked body of inspectors and guards, fly down to Southampton and back at four-minute intervals. The afore-mentioned officials, occupying an observation saloon car hitched to the tail of the second train, make careful notes about the running of the train as far as it concerns their particular departments.

Of course, everybody all down the line is on the alert for the specials to pass, just as they will have to be when the great performance takes place. Every signal cabin (including the five new temporary ones) is switched in, and the signalman at each displays a blackboard, on which is chalked the exact hour at which the preceding special passed his box, so that the driver of the passing train may know how much leeway he has got.

The task of piloting the long and heavy trains through the docks themselves to the different berthing stations is also being rehearsed. There is a railway all around the docks, with curves appallingly sharp. On arriving at the docks the express engines will go off, and the couplings

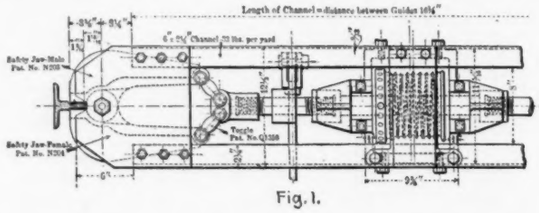

Length of Channel=distance between Guides 16¼"
Safety Jaw-Male Pat. No. N355
Safety Jaw-Female Pat. No. N354
Toggle Pat. No. Q358

Fig. 1.

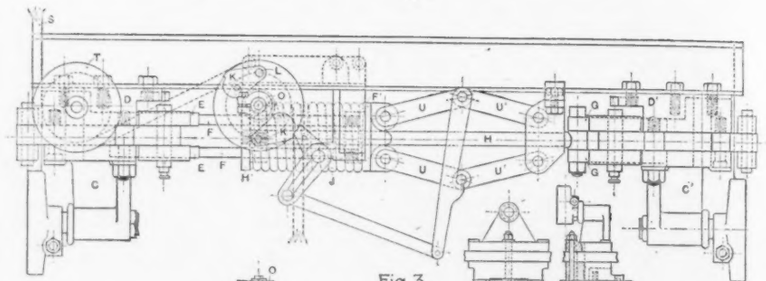


Fig. 3.

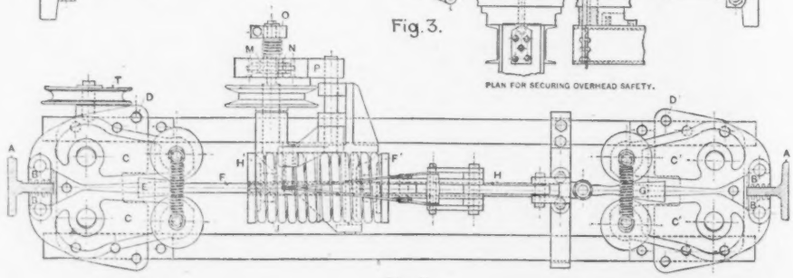


Fig. 2.

FIGS. 1, 2 AND 3. ORIGINAL FORMS OF SAFETY DEVICES FOR ELEVATORS.
(Reproduced from Trans. Am.. Soc. M. E. Vol. XX., pp. 811 and 815.)

precaution will be taken of having spare engines, waiting under steam, at various points along the line.

In 1897, in order to augment the track capacity, many additional block sections were inserted between Woking and Southampton, all of which, owing to the increase of ordinary traffic, have since become permanent. With a series of trains running at four-minute intervals, however, five additional block sections will be required. The signal cabins and signals have already been erected, the work being carried out within three days. Consequently, on the Naval Review day, the London and Southampton main line will be divided into 80 block sections, and for many consecutive hours each block section will be occupied by a train, for, in addition to the specials, many of the ordinary trains will have to be run.

Great works have been in progress for three years past in connection with the construction of a four-track way between London and Southampton. Several sections of this undertaking are already open for traffic, and it is intended to open several more in time for the review throughout the train be loosened, otherwise the rolling stock would never negotiate the curves. Lilliputian dock engines will then couple on in front and behind, and haul the train to the steamer side.

The docks are to be divided into four sections, the first special running into No. 1, the second into No. 2, and so on; hence each train will have 16 minutes in which to unload and shunt clear before that section is required again.

ELEVATOR SAFETIES.*

By Charles R. Pratt, M. Am. Soc. M. E.†

In my paper on "Elevators" presented at our meeting in Washington in May, 1899, Vol. XX., p. 804, I described two devices‡ (Figs. 1, 2 and 3) which up to that time were

*Abstract of a paper presented at the Boston meeting of the American Society of Mechanical Engineers.

†Montclair, N. J.

‡Figs. 1, 2 and 3 are reproductions of Figs. 275, 278 and 279 in the paper referred to.

best known means of stopping an elevator car by gripping steel guide rails. These two devices were then far superior to anything else that had ever been used for this purpose, that their defects, while well known to the author, were not fair subjects for criticism. Now, however, as these two devices represent the two general principles common to all methods of gripping a steel guide rail, their defects must be described in order to show why and how they have been overcome.

In the first place, let the author confess, with due humility, that there is probably not one man, with a well balanced mind, a due regard for his life, and a thorough knowledge of elevator safeties, that would get in an elevator car and have the ropes cut and depend upon any of these aforesaid safeties to let him down easy. And while I am not, at the moment of writing, prepared to say that I am willing to prove the reliability of my latest type of safety, by being in the car when the ropes are cut, I can report unofficially that the draftsmen, the foremen, and machinists, do this for fun when I am not around to prevent it, which is a tribute of confidence never paid to any other elevator safety. I cite these incidents to show the necessity for improvement in this very important function of protecting the lives of the millions of people who daily ride in elevators. And the fact that elevator accidents are of rare occurrence, is no excuse for inadequate means of stopping the car in case of any accident to its hoisting apparatus.

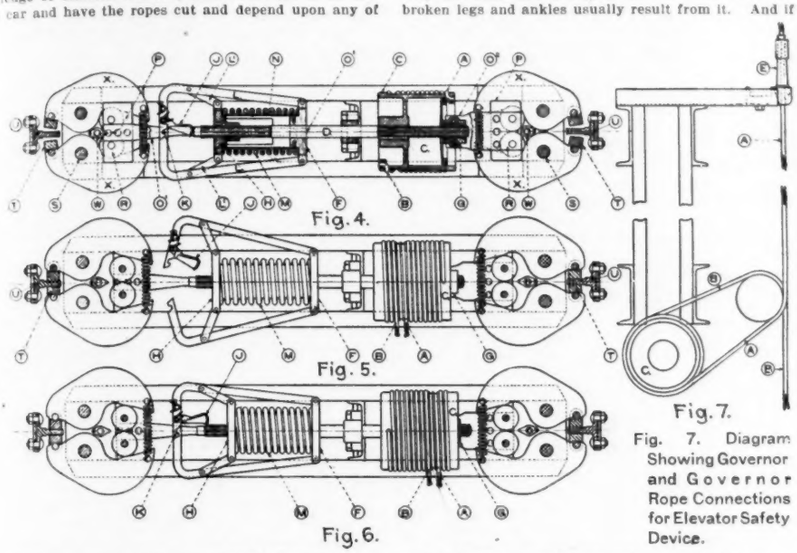


Fig. 7. Diagram Showing Governor and Governor Rope Connections for Elevator Safety Device.

FIGS. 4, 5 AND 6. IMPROVED FORMS OF SAFETY DEVICES FOR ELEVATORS.

Owing to the fact that nearly all elevator accidents are due to failure of the hoisting machinery and not to the breaking of the ropes, and, therefore, the car speed accelerates too gradually to slacken the ropes sufficiently to operate a safety by means of slack hoisting ropes, the safety must be operated by some form of speed governor. The next consideration is, with what shall the device on the car engage to stop its fall easily? My former paper on elevators described about all the different means used for this purpose, and experience seems to prove that the guide rails, wood or steel, are the best supports for a gripping device on the car to engage. Experience also shows that a centrifugal speed governor is the best means of operating the safety.

We have then as a base of operation: (1) Centrifugal force, absolute and controllable; (2) Steel guide rails of ample strength, smooth and well lubricated; (3) Power to grip the rails, either by the travel of the car, which is absolute and unlimited for this purpose, or by the stored energy of springs, which is limited. These are certainly ample means to accomplish with absolute reliability the function of stopping an elevator car easily when it is otherwise free to fall. To what defective mechanism then is due the fact that this has not yet been accomplished, except by the device which will be described later on in this paper.

Reference to Fig. 1 will clearly demonstrate one radical defect in one device, viz: The gripping power in this instance is applied entirely by the travel of the car, revolving a drum by means of a rope which is gripped by a centrifugal governor secured to the hoistway beams. This drum revolves a shaft having a right hand screw on one end and a left hand screw on the other end. Nuts on these screws engage toggles, which engage levers which grip the rails, as shown in Fig. 1. Consider now what occurs when the car through excess of speed, sometimes as high as 800 to 1,000 ft. a minute, causes the centrifugal governor to operate and grip the rope which revolves the drum. First, the necessary clearance, at least ¼-in. between ends of levers and guide rails, must be overcome, and more than one revolution of the drum is required to do this, anywhere from 4 to 8 ft. travel of the car in actual practice is necessary to bring the ends of these levers in contact with the rails, and the speed may then be 1,500 ft. per minute. Secondly, when the ends of these levers come in contact with the rails, if the car speed is to be gradually reduced through a sufficient distance to avoid injury to the passengers, the car must continue to travel, the drum to revolve, and the levers to bend, until that distance is overcome. Can toggles be adjusted, and the wear of the levers on the rails be compensated for to accomplish this as a practical device? Most certainly not. What actually happens is a permanent set to the levers as they are bent, and a stop in such a short distance that broken legs and ankles usually result from it. And if not readjusted or repaired, after a few operations at high speed and heavy load, it becomes inoperative.

Reference to Figs. 2 and 3, will demonstrate the defects in one other device, and here the author criticises his own design: The defects in this type of safety are the limited power of the spring and the suddenness of its stop with light loads, the severity of the hammer blow with which the spring operates the safety, and the consequent lack of durability. The limited power requires frequent inspection and adjustment to keep it in operative condition. When such inspections and adjustments are faithfully and competently made, the safety is reliable, and grips the rails instantly the normal car speed is exceeded, and never stops the car suddenly enough to injure the passengers, although its stop with a light load is not a comfortable one. About 25 operations without adjustment would make this safety inoperative, and $^1/_{32}$-in. wear on the jaws, which occurs when the regular guide shoe is allowed to wear too far, will also make it inoperative. We have, therefore, defects in both of these devices which preclude their claim to being adequate safeties to stop an elevator, with safety and comfort to the passengers, under any and all conditions of actual daily practice.

Reference to Figs. 4 and 5, will clearly demonstrate that all of the defects cited in these other two safeties have been entirely overcome, and a radically new principle introduced to properly and safely stop an elevator car by gripping the steel guide rails. Figs. 4 to 6 show my new type of safety in plan, looking up at the bottom of the elevator where it is carried. Fig. 7 is an elevation showing the governor rope connection. Fig. 8 is a half-tone of the centrifugal governor. That part of the rope A, which runs through the grip A′, leads to the elevator car, passing through a driving grip E (Fig. 7); it is then led under an idler on the bottom of the car, wound around the drum C and anchored at A (Fig. 4). The other part of the rope B (Fig. 8) leads down to and around a weighted tension sheave at the bottom of the hoistway, from thence up to and over an idler sheave on the bottom of the car, and from there it is wound around the drum C and anchored at E (Fig. 4).

The grip, E (Fig. 7), is held by a light spring bolt, and when the car speed down causes the governor to grip and stop the rope, the grip E pulls out of its bolt lock. The speed at which the centrifugal governor weights, Y (Fig. 8), will fly out and drive the grip down on the rope as shown in Fig. 8, is determined by the tension of the spiral spring Z, the same being adjusted by nuts not shown here.

The operations in order are viz:

The car in its descent exceeds its normal speed by about 10%, the governor grips the rope, A, and stops it; the car continues its travel, pulling the latch bolt out of grip E (Fig. 7); the rope A revolves the drum C; the drum C winds up the rope B; the drum C revolves the shaft D in the direction to cause it to draw both right and left hand nuts H and G (Fig. 4) towards each other; at the first advance of the right hand thread through the nut H, the end of the shaft D forces the push bar J (Fig. 4) to the left and trips the latch K; latch K being tripped allows the spring M to extend as shown in Fig. 5, and brings the jaws T in contact with the guide rails U, within less than 2 ft. travel of the car after the rope A is stopped. Further travel of the car compresses the spring M, bringing a steadily increasing pressure of the jaws T upon the rails U, until the car is easily stopped. To release the safety, the drum C is further revolved in the same direction by hand pull on the governor rope, until the latch K is relatched, as shown in Fig. 6.

It should be observed here that push bar J clears the path of the screw when the latch K is sprung (see Fig. 3), and when returned, as shown in Fig. 6 it bears against the screw by pressure of a light spring which snaps it back into position, as shown in Fig. 4, when the drum C is revolved in the reverse direction by hand pull on rope B, and the nuts H and G forced apart to their original positions, as shown in Fig. 4. The following essential conditions are, therefore, obtained:

(1) A centrifugal governor of the utmost simplicity and reliability; (2) The stored energy of a spring to bring the jaws instantly in contact with the rails, but with a pressure and hammer blow too light to jar the passengers or injure any part of the safety; (3) The steady increase of pressure of the jaws on the guide rails through any distance of car travel necessary to bring the car to a safe and easy stop. And this is done by the normal closing of a helical spring, and not by the bending of parts which are not springs.

This safety has had several hundred successive free fall tests without a single failure, with no injury whatever to any part, and with no adjustment to any part. These tests were made at all speeds up to 800 ft. per minute, and 5,000-lb. loads. Its load capacity is only a matter of dimensions, and I think this safety will stop on a free fall about three times the load that any other safety of its own weight will stop. I have trusted to the completeness of these drawings to make plain the details without further description, but I will call attention to the particular advantage of this cam lever action over the wedge or toggles. In the first place, the rolls R start with a short leverage on the cam levers X, which permits a greater motion of jaws T, with the limited motion of the rolls R, and in the second place the enormous pressure on these rolls is taken by their rolling contact on each other, instead of on the pins which carry them.

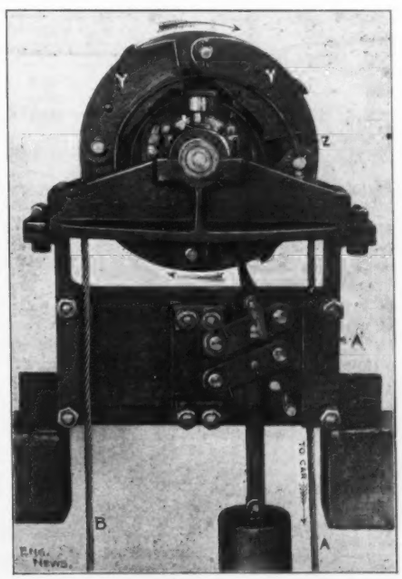


Fig. 8. Improved Form of Centrifugal Governor for Actuating Elevator Safety Device.

The curve on the ends of the cams give the equivalent motion of straight line wedges; thus if through imperfect adjustment, or unequal wear, the rolls on one end travel farther than those at the other end of the safety, the pressure of the jaws T is alike on both guide rails U. Another important feature of this safety is that it is easily released from any part of the hoistway accessible to the governor rope, no means being provided to release it from the car. As nothing but undue car speed should ever operate this safety, it is advisable that the engineer should find out the cause of this undue speed, and see that everything is in proper condition to start before the safety is released.

Bending each end (A and B) of the governor rope around

the drum C in opposite directions (Fig. 7) puts the drum C under positive control of the governor rope. The ease with which this safety can be operated was well demonstrated during the free fall tests; the operations were: (1) Trip the hook and let the car fall; (2) Lower the hook, make fast and put a tension on the ropes; (3) Release the safety by the governor rope; (4) Hoist the car to the tripping place. Twenty-eight of these free falls were made in 28 minutes.

BELT-POWER BOILER FEED PUMP WITH VARIABLE STROKE.

The pump shown in the accompanying illustrations embodies an interesting novelty in principle of action. The "Leitch" pump, as it is called, is designed particularly for boiler feeding, and is belt-driven, either directly or geared. Belt-driven pumps are preferred to separately steam-driven pumps, because of greater economy for small capacity service like boiler-feeding; they have, however, the disadvantage of pumping a fixed amount of water at all times, since their speed and their displacement are constant. As the water required by a boiler varies greatly at different times, means must be adopted to suit the pumpage to the demand. Usually a valve-regulated by-pass around the pump is provided by which a certain part of its discharge flows back to the suction side; sometimes the pump is not fitted with a by-pass, but is simply run intermittently, the water-level in the boiler thus varying between upper and lower limits.

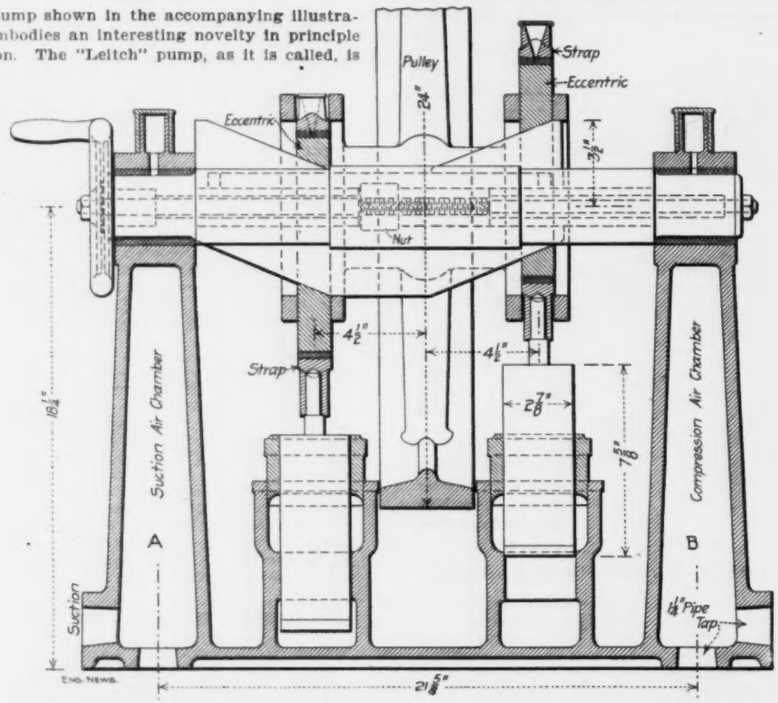


FIG. 1. LONGITUDINAL SECTION OF LEITCH PATENT VARIABLE-STROKE BOILER FEED PUMP.
Cameron-Tennant Machine Works, Richmond, Va., Builders.

Fig. 1 shows a vertical section through the center line of the shaft of a 2⅞ × 3-in. Leitch pump. There are two water cylinders and plungers, arranged vertically; the driving shaft is at the top of the machine, and as shown bears a pulley at the middle. The plungers are actuated through rods by eccentrics mounted on the shaft to either side of the pulley. These eccentrics are so arranged that they can be shifted toward or from the center of rotation; in this way their throw, and correspondingly the stroke of the plungers, can be varied. The figure shows this arrangement. Pairs of wedges sliding in longitudinal slots cut in the shaft pass through narrow openings or seats in the eccentrics and bear against the latter. The shaft is hollow, and through the central hole passes a screw provided with nut and washer at one end and a handwheel at the other.

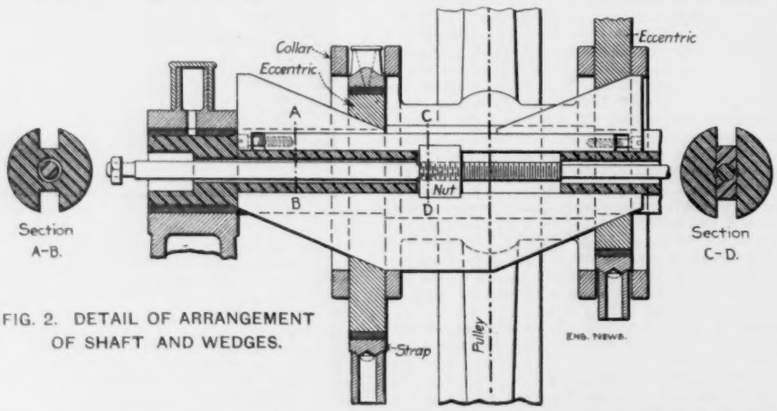


FIG. 2. DETAIL OF ARRANGEMENT OF SHAFT AND WEDGES.

The pump here described accomplished this object in a different manner. The pump is intended to be run without intermission at constant speed; the stroke of the plungers, and hence their displacement, can be varied from zero to maximum so as to adjust the pumpage to the requirements. This adjustment of the stroke, moreover, is very simple, being produced by merely turning a handwheel, and this can be done while the pump is running. The variable stroke of the pump, and the mechanism by which it is secured, form the novel features of the machine.

At the middle of its length the screw bears a nut, which plays in an opening formed in the shaft at its center; the nut engages the pairs of wedges upon which the eccentrics are carried. Evidently when the screw is turned by means of the handwheel, the nut will slide, in one direction or the other, longitudinally to the shaft; the nut pulls the pairs of wedges with it, and slides them transversely to the eccentrics. The latter are thus shifted across the shaft by the action of the wedges against their inclined seats in the eccentrics, and in this way their throw is varied and the discharge of the pump regulated.

The whole wedge-shifting arrangement is shown more clearly in Fig. 2, which represents a longitudinal section through the shaft, with screw, nut, and wedges in place. In the same figure are shown transverse sections of the shaft at two points, and these will make apparent the construction of the shaft. Shallow longitudinal slots cut in the shaft on opposite sides form the guides for the wedges. In the middle of the shaft the slot extends clear through, and in this opening the nut moves which actuates the wedges. The lower wedge is in one piece, and engages the nut directly; the upper wedge consists of two triangular pieces fastened by screws to a carrier strip which engages the nut. It will be noticed that by means of these screws the two half wedges of the upper wedge can be drawn together or spread apart; it will be seen that in this way any wear of the wedges or of their seats in the eccentrics can be taken up.

There is further provided a locking-pin on the handwheel, by means of which the latter, and with it the shifting screw, is locked to the shaft, except when released by hand, so that no accidental movement of the wedges can occur. The plungers and their eccentrics are set 180° apart, which accounts for the opposite setting of the pairs of wedges.

Other details of interest in the machine are the following: The standards supporting the shaft-bearings are cored out, and their interior spaces are utilized as air-chambers; the standard shown on the left forms the suction air-chamber, the one on the right the compression or discharge air-chamber. The valve-cases are set on the transverse center line of the machine, on opposite sides; each has a suction and a discharge valve, one above the other, with the pump connected to the space between. It may be remarked that the base-casting of the pump, through which the water passages are cored, is not shown in Fig. 1. The connection of the plunger-rods to the plungers is by means of a ball-and-socket joint. The plungers are made of hard-drawn brass tubing and the socket is formed in two blocks screwed into the bottom, which blocks also form the plunger-head.

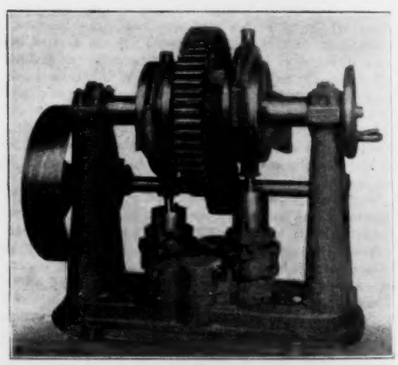


Fig. 3. General View of Leitch Variable-Stroke Pump, Geared Pattern.

Fig. 3 shows a general view of a 4 × 4-in. Leitch pump. This pump differs from the one shown in the sectional drawings by having a gear in place of the pulley mounted on the pump-shaft, and driven from a pinion on a separate pulley-shaft. The Leitch pump is built by the Cameron-Tennant Machine Works, of Richmond, Va., to whom we are indebted for the matter from which our illustrations and description were prepared.